



Durham E-Theses

Feeding and failure to thrive in early infancy

Colquhoun, Fiona

How to cite:

Colquhoun, Fiona (2003) *Feeding and failure to thrive in early infancy*, Durham theses, Durham University.
Available at Durham E-Theses Online: <http://etheses.dur.ac.uk/4000/>

Use policy

The full-text may be used and/or reproduced, and given to third parties in any format or medium, without prior permission or charge, for personal research or study, educational, or not-for-profit purposes provided that:

- a full bibliographic reference is made to the original source
- a [link](#) is made to the metadata record in Durham E-Theses
- the full-text is not changed in any way

The full-text must not be sold in any format or medium without the formal permission of the copyright holders.

Please consult the [full Durham E-Theses policy](#) for further details.

Author: Fiona Colquhoun

Abstract: Feeding and Failure to Thrive in Early Infancy

Ph.D 2003

The aims of this thesis were fourfold. The first aim was the early identification of cases of non organic failure to thrive in a community based study and of randomly selected controls. Cases and controls were identified at six weeks of age using Thrive Index (Wright et al, 1994). The Thrive Index was used to measure growth velocity from birth to six weeks using two weights (birth weight and six weeks weight).

The second aim was to analyse the familial characteristics of case and control families to investigate whether the frequency of failure to thrive over this period was higher in more deprived families, or families with other social characteristics. The characteristics recorded were maternal education, wage earning status, home and car ownership number of previous children and religious affiliation. The results showed that there were no statistically significant differences between the two groups or any of these variables.

The third aim was to investigate the early feeding behaviour of the case and control infants. This was done using two separate approaches. The first was a six week feeding questionnaire given to all mothers asking them to provide information about their infant's feeding behaviour. Case infants were more likely to be fed on demand than set times (Chi-square = 5.035, df=1, p=0.025). Also, mothers of cases reported their infants' appetite to be poorer than that of controls (Mann-Whitney U = 1494, z=-2.179, p=0.02). The second approach was to directly observe and measure the infants feeding behaviour when the infants were aged between eight and twelve weeks. This was carried out blind to eliminate experimental bias. The sucking behaviour was analysed using a method described in Woolridge and Drewett (1986). Cases and controls did not differ on any of the recorded sucking behaviour characteristics.

The fourth aim was to monitor the growth of cases and controls over one year. Using regression analyses it was found that only sex predicted weight gain to the end of the first year.

Feeding and Failure to Thrive in Early Infancy

Fiona Colquhoun

**A copyright of this thesis rests
with the author. No quotation
from it should be published
without his prior written consent
and information derived from it
should be acknowledged.**



- 2 JUN 2004

Table of Contents

Abstract	i
Table of contents	iii
List of tables	ix
List of figures	xii
Declaration	xvi
Statement of Copyright	xvi
Acknowledgements	xvii

Chapter One

1. Introduction and literature review	1
1.1 Definition and origins of failure to thrive	2
1.1.1 Normal and abnormal growth in infancy	3
1.1.2 Threshold based criteria of abnormal growth	8
1.1.3 Changes in centile position to identify failure to thrive	9
1.1.4 Identifying failure to thrive using a velocity measure	11
1.1.5 Summarising failure to thrive	12
1.2 Factors that impair infant growth	13
1.2.1 Physiology of sucking behaviour	14
1.2.2 Physiological causes of inefficient sucking behaviour	16
1.2.3 Oral motor dysfunction	18
1.2.4 The origins of feeding disorders in infancy	24
1.2.5 Internal regulatory problem	32
1.2.6 Environmental factors that impair growth	37

1.2.7	Summary of factors that impair growth	49
1.3	Feed type and infant growth	50
1.3.1	Feed type and its affect on development	56
1.3.2	Time of weaning and predispositions to feeding styles	59
1.3.3	Summary of feed type and infant growth	61
1.4	Studying infant feeding behaviour	61
1.4.1	Nipple units and milk flow	67
1.4.2	Clinical application of studying sucking behaviour	69
1.5	Summary and aims	70

Chapter Two

2. Methods	73
2.1 The Millennium Baby Study	74
2.1.1 Recruitment	75
2.2 Identifying early onset of failure to thrive	77
2.2.1 Identifying case and control infants	78
2.2.2 Attrition	83
2.3 Methods for studying infant feeding behaviour	84
2.3.1 Apparatus and questionnaires	85
2.4 Procedure	92
2.5 Analysis	98
2.5.1 Growth data	100
2.5.2 Familial characteristics	102
2.5.3 Mothers' reports of milk feeds	103
2.5.4 Observational data	103
2.5.5 Formula milk samples	106
2.6 Summary	108

Chapter Three

3. The study sample: Weight gain and the characteristics of the families	110
3.1 The identification of failure to thrive	111
3.2 Comparing the familial characteristics of case and control infants	118
3.2.1 Maternal education	120
3.2.2 Wage earning in the household	122
3.2.3 House ownership	124
3.2.4 Car ownership	126
3.2.5 Number of previous children	128
3.2.6 Religious affiliation	130
3.2.7 Summary	131
3.3 Comparison of the familial characteristics of infants followed up and infants not followed up between eight and twelve weeks	132
3.4 Summary	134

Chapter Four

4. The analysis of feeding questionnaire data (6 weeks)	135
4.1 Introduction	136
4.2 General feeding questions	137
4.3 Volume and duration	144
4.4 Appetite	147
4.5 The feeding situation	151
4.6 Oral motor problems	154

4.7	Regulation of intake	157
4.8	Body image	159
4.9	Analysis of infants followed up and infants not followed up	161
4.10	Effect size and power	169
4.11	Summary	170

Chapter Five

5. Analysis of feeding behaviour for the observational study (8–12 weeks)	172
5.1 Introduction	173
5.2 Recording sucking behaviour	174
5.2.1 The sucking behaviour of infants from the Millennium Baby Study	179
5.3 Exploring other feeding variables	186
5.4 Weight at visit and the influence of other variables	191
5.5 Reconstitution of milk samples	197
5.6 The feeding diaries	202
5.7 Summary	208

Chapter Six

6. Weight gain over the first year	210
6.1 Introduction	211
6.1.1 The weight data available for research	212
6.2 Do cases identified at six to eight weeks fail to thrive	216

	over the first year?	
6.3	The influence of other variables on weight gain over the first year	223
6.4	Summary	228

Chapter Seven

7. Discussion		229
7.1	Introduction	230
7.2	Identifying failure to thrive in early infancy	231
7.3	Familial characteristics of cases and controls	233
7.3.1	Maternal education	234
7.3.2	Wage earning, house and car ownership	236
7.3.3	Number of previous children	238
7.3.4	Religious affiliation	239
7.3.5	Summary	240
7.4	The feeding behaviour of cases and controls	240
7.4.1	Reported feeding behaviour	241
7.4.2	General feeding questions	242
7.4.3	Intake and duration of feeds	243
7.4.4	Feeding situation	245
7.4.5	Oral motor problems and the regulation of intake	249
7.4.6	Body image	250
7.4.7	Appetite	251
7.4.8	Objectively recorded feeding behaviour	255
7.4.9	Sucking behaviour	255
7.4.10	Feed type	257
7.4.11	Intake and duration of feeds	258
7.4.12	Formula concentration	263
7.4.13	Objectively recorded and reported behaviour	265
7.4.14	Summary	265
7.5	Growth over the first year and the influence of feeding	266

behaviour on weight gain	
7.6 General themes	270
7.6.1 Sampling techniques	271
7.6.2 Methodological issues	273
7.7 Future research	276
References	278

List of tables

2.2.2	Analysis of cases and controls according to willingness to participate	84
2.4a	Summary of data collected for breast fed infants	95
2.4b	Summary of data collected for bottle fed infants	97
2.5a	Summary of information analysed in the study	99
2.5.4a	Summary of type commands for Minkey	104
3.1a	Number of subjects studied within each group	113
3.1b	Mean and standard deviation for birth and six week weight for cases and controls	118
3.2.1	Maternal educational attainment of cases and controls	121
3.2.2	Wage earning in cases and controls	123
3.2.3	Home ownership in cases and controls	125
3.2.4	Car ownership in cases and controls	127
3.2.5	Number of previous children in cases and control Families	129
3.2.6	Religious affiliation in cases and controls	131
3.3	Frequency data for responses made by mothers of cases and controls	133
4.2a	Frequency of feed type within each group	138
4.2b	Frequency of feeding schedule within each group	140
4.2c	T-test results for number of feeds per 24 hours for cases and controls	141
4.2d	Chi-square analysis for bottled milk	143
4.3a	Frequency of responses for estimated volume intake	145
4.3b	Estimated feed duration of feeds	146
4.4a	Questions related to appetite and the scoring procedure for answers	149
4.4b	Mann-Whitney u test results for appetite score for cases and controls	150

4.5a	Questions related to the feeding situation and the scoring procedure for answers	152
4.5b	Mann-Whitney U test results for the feeding situation score for cases and controls	153
4.6a	Questions related to oral motor problems and the scoring procedure for answers	155
4.6b	Mann-Whitney U test results for oral motor problems	156
4.7	Analysis of questions relating to the regulation of intake	158
4.8	Mothers' rating of their infant's body fat	160
4.9a	Summary of analyses of general feeding questions for infants not followed up and followed up	163
4.9b	Summary of analyses for estimated volume intake and duration of feeds	165
4.9c	Summary of analyses for infants followed up and infants not followed up	168
5.1a	Summary of feeding behaviour for two consecutive feeds in a randomly selected control infant from the study	179
5.2.1a	Correlation results for Feed 1 and Feed 2	180
5.2.1b	Summary of U test for cases and controls for feeds	186
5.3a	Feed type in cases and controls	188
5.3b	T-test results for mean duration of feeds and mean mass consumed, for cases and controls	191
5.4a	T-test results for weight during the observational study for cases and controls	193
5.4b	Change statistics for weight gain from birth to observational study on sex, birthweight, feed type, sucking parameters and mean mass consumed and mean duration of feeds	195
5.4c	Regression analysis of weight gain to the observational study on birthweight, sex, feed type, sucking	196

	parameters and mean mass and duration of feeds.	
5.5a	Mean ratio of dried matter found in milk to standard measure	198
5.5b	Correlation of reconstituted formula ratios for feed 1 and feed 2	199
5.5c	T-test results comparing mean ratios for two feeds in cases and controls	200
5.6a	Feeding diary for a bottle fed infant	203
5.6b	Complementary feeds in cases and controls	204
5.6c	Means and standard deviations for the reported number of feeds, feed duration, and volume consumed over 48 hours. The average number of feeds in which problems were reported is also shown	205
5.6d	Results of Pearson correlation investigating reported feed time and volume consumed with the observed data (collected by the experimenter) for these measures	208
6.2a	Regression analysis of birthweight, sex and status on weight gain to the end of the first year	221
6.2b	Frequency of case and control status from six weeks over the first year	222
6.3a	Change statistics for weight gain to the end of first year using birthweight, sex, feed type, mean mass consumed at feeds (g), mean duration(s) of feeds and sucking parameters	226
6.3b	Regression analysis of birthweight, sex, age, feed type, mass and duration and sucking parameters on weight gain to the end of the first year	227

List of figures

2.1	Subjects studied	82
3.1	Plot of z score for weight at six weeks against z score for weight at birth for female cases and controls	113
3.2	Plot of z score for weight at six weeks against z score for weight at birth for male cases and controls	114
3.3	Distribution of birth weight and six week z scores for female cases and controls	116
3.4	Distribution of birth weight and six week z scores for male cases and controls	117
3.5	Maternal qualifications in cases and control	120
3.6	Wage earning in cases and controls	122
3.7	House ownership in cases and controls	124
3.8	Car ownership in cases and controls	126
3.9	Number of previous children in cases and controls	128
3.10	Details of religious status in cases and controls	130
4.1	Frequency of responses for feed type	138
4.2	Frequency of feeding schedule	139
4.3	Frequency of feeds for cases and controls during a 24 hour period	141
4.4	Frequency of responses for whether the infant received bottle milk	143
4.5	Frequency of responses for volume intake in bottle feeders	145
4.6	Frequency of responses for estimated duration of feeds	146
4.7	Frequency of reported problems on appetite questions	149
4.8	Number of problems reported on the feeding situation	153
4.9	Number of problems reported for oral motor problems	156

4.10	Number of reported problems for the regulation of intake	158
4.11	Frequency data for body image	160
4.12	Distribution of answers for general feeding questions	162
4.13	Distribution of volume and duration of feeds in infants followed up and not followed up	164
4.14	Comparison of infants followed up and not followed up	166
5.1	Graph showing the intervals between sucks during the course of one feed in a bottle fed control infant	176
5.2	Graph showing the intervals between sucks during the course of one feed in a bottle fed case infant	176
5.3	Distribution of mean number of sucks per burst for the start and the end of the feeds for cases (n=19) and controls (n=30)	182
5.4	Distribution of mean suck duration for the start and the End of the feeds for cases (n=19) and controls (n=30)	183
5.5	Distribution of mean suck duration S.D. for the start And the end of the feeds for cases (n=19) and controls (n=30)	184
5.6	Distribution of mean pause length for the start and the end of the feeds for cases (n=19) and controls (n=30)	185
5.7	Number of infants receiving breast or bottled milk during the observational study	188
5.8	Mean mass consumed according to group	189
5.9	Mean duration of feeds according to group	190
5.10	Weight at visit for cases and controls	192
5.11	Distribution of mean ratio for reconstituted formula for cases and controls	201
5.12	Graphs showing reported and objectively recorded time and intake in cases and controls	207
6.1	Summary of weight data available at about six	213

	weeks, four months and twelve months for case and control infants	
6.2	Growth trajectory of cases and controls from birth to twelve months	215
6.3	Birthweight and 12 month z scores for female cases and controls as identified at the 6 week check	218
6.4	Birth weight and 12 month z scores for male cases and controls	219
6.5	Distribution of weight at about one year for cases and controls	220
6.6	Procedure for incorporating variables to predict weight using regression analysis	225

Appendices

1. Written information for health visitors
2. Information sheet for expectant mothers
3. Consent form for Millennium Baby Study
4. Recruitment questionnaire
5. Six week questionnaire
6. Additional information sent to health visitors
7. Letter to mothers about the observational feeding study
8. Information sheet for mothers
9. Consent form for mothers
10. Milk diary
11. Data sheet for breast fed infants
12. Data sheet for bottle fed infants
13. Teat information
14. Brand information

Declaration

The research contained in this thesis was carried out by the author between October 1998 and April 2002 whilst a postgraduate in the Department of Psychology at the University of Durham. None of the work contained in this thesis has been submitted in any form in candidature for any other degree.

Statement of Copyright

The copyright of this thesis rests with the author. No quotation from it should be published without their prior written consent and information derived from it should be acknowledged.

Acknowledgements

I would like to acknowledge the support of the Millennium Baby Study team for all of their help throughout the duration of my research. I want to thank Dr. Charlotte Wright for her advice throughout. I would like to thank Dr. Sally Corbett for being an invaluable friend and colleague. Finally I would like to acknowledge the support of my family.

Dedication

This is dedicated to my son, Tristan.

Chapter 1:

Introduction and literature review.



Chapter 1

Introduction and literature review

1.1 Definition and origins of failure to thrive

The definition of failure to thrive typically includes a reference to poor growth, for example, failure to sustain normal growth in the first three years of life (Frank & Zeisel, 1988) or a fall below the third centile (Bachelor, 1999) or reduced growth velocity (Wright et al, 1994). The origins of failure to thrive are difficult to pinpoint since research indicates a number of factors as potential causes. It can have an organic cause or it can have non organic cause. Historically, failure to thrive has been associated with abuse or parental neglect (Spitz, 1945). However, early research into failure to thrive has restricted the investigation to hospitalised cases and are therefore not representative of all cases of failure to thrive (Drotar, 1990). It has been assumed that if no organic cause could explain the poor growth, the problem must be due to emotional deprivation (Frank & Zeisel, 1988). Using a binary definition of organic and non organic can prove difficult since it is becoming increasingly recognised that failure to thrive is a result of multiple factors interacting together, these can be both environmental and biological (Steward & Garvin, 1997). Failure to thrive infants often consume food, yet fail to gain weight, and this led researchers during the 1950's to argue that deprivation induces poor functioning of the endocrine system, and food to be poorly absorbed (Skuse et al, 1994a). A number of studies have shifted research attention away from deprivation theories and argue that failure to thrive can be explained by insufficient intake (Whitten

et al, 1969). Insufficient intake may be the result of inadequate access to food, or inadequate acceptance of food.

The problems with much of the research on failure to thrive is that the samples are collected from clinical settings, and are therefore full of extreme cases of neglect and poor parenting (Dubowitz, 1989; Bachelor & Kerslake, 1990). This type of research helped to develop the theory that failure to thrive was a consequence of deprivation. Controlled studies have shown that poor mother child interactions are not more common in failure to thrive homes than in controls (Altemeier et al, 1984; Bithoney et al, 1995). Following on from this, researchers have looked at other factors to explain the origins of failure to thrive. For example, is the child inherently difficult to feed (Skuse, 1985; Humphry & Rourke, 1991; Wolf & Glass, 1992)? Is the temperament of the infant causing poor communication at meal times (Powell 1983; Berkowitz & Senter, 1987; Mathisen et al, 1989; Chatoor et al, 1997). Developing such theories would need close observation of meal time behaviour. Some studies have done this but there is an absence of research conducted on the younger failing to thrive infant.

1.1.1 Normal and abnormal growth in infancy

Although poor growth is the basic criterion for failure to thrive, the identification of poor growth differs from one publication to another. The clinical record of an infant generally shows a birth weight and a six week weight, length and head circumference. All of these data are plotted on growth charts. Weight for age, or weight plus length and head circumference, can be used as an indication of growth.

The weight chart consists of two axes, one showing weight (y axis), the other age in months (x axis). A number of centile lines (e.g. 3rd, 10th, 50th, 90th and 97th) are displayed that denote the distribution of weight for age in the population. The 50th centile line indicates that 50% of infants in the population are above this line and 50% are below this line. The 3rd centile indicates that 3% of the population are below this line while the remaining 97% are above this line.

Comparing an infant to the rest of the population becomes more complex in special cases. For example, pre term infants are lighter at birth than term infants. Therefore more pre term infants would fall into the category of failure to thrive if the paediatricians used attained weight (i.e. at three months the infant weighs so much) as criteria, for failure to thrive, without taking length of gestation into account, so an adjustment for this is routinely made. Alternatively, serial weights are sometimes used, birth weight, weight at 6 weeks etc. This enables the clinician to track an infant's growth over time. No matter which of these two measures is used, whether or not the infant is identified as failing to thrive will depend upon the comparison group.

It is better to examine pre term infant growth separately from term because the infants are naturally smaller. However, developing a suitable growth chart for pre term infants has been difficult. The first task is to discover the birth weights of infants born at different gestational stages. This simple task is made more difficult when gestational age cannot be accurately assessed, especially if the source of information on age comes primarily from mothers' reports of their last period. For any research it is unwise to use mothers' report alone and this was addressed by Keen & Pearse (1985). The researchers included additional measures such as obstetrician examination, early ultrasonography and paediatric assessment. From their findings a growth chart was devised that showed

more accurately the birth weight per gestational week. From this chart they defined an infant as suffering from impaired growth if their weight fell below two standard deviations of the mean for that particular gestational age.

Once a chart has been devised for birth weight according to age, a suitable chart displaying post natal growth is needed. A number of different studies have tackled this. However, estimates of growth were impaired since the studies did not take into account gestational age (Shaffer et al, 1987). Other studies have taken into account gestational age (Wright et al, 1993; Gill et al, 1986; Brandt, 1985) and consequently their findings differ. For example Shaffer et al (1987) found that all infants, regardless of gestational age gained weight at a similar rate. Gill et al (1986) found that the more premature the infant the slower the weight gain, whereas Wright et al (1993) found that of a sample of very low birth weight infants, the lowest birth weight group gained weight at the fastest rate. Similarly, there is debate about whether the infants grow at the same rate as they would have done in utero or if they grow quicker than in utero after 4 weeks postnatally (Gill et al, 1986). Brandt (1985) found that pre term infants had retarded growth until the expected day of delivery, after which they grow at the same rate as they would have.

Feed type is often targeted as the cause of differences observed in the growth of pre term infants. If the pre term infant was given enhanced feeds would they grow as they would have in utero? The use of specialist feeds is an interesting point that may explain the discrepancies between the results of the above studies. Gill et al (1986) grouped all infants together regardless of feed type or observed illness. Wright et al (1993) discusses the point that formulas and the health status of the infant i.e. whether they required ventilation etc, may explain the variability between these growth studies. In sum, the results obtained depend upon how the infants are grouped: gestational age or

weight (Shaffer et al, 1987) or both (Wright et al, 1993; Keen et al, 1985), sick or well infants, or specific socio-economic group (Babson et al, 1970) or feed type. Some studies have noted differences in growth between infants whose weight is age appropriate for gestation (AGA) and those small for gestational age (Brandt, 1985) while others have not (Cook et al, 1993).

Tanner et al (1966a, 1966b) developed a post natal growth chart from data collected on a number of bottle fed infants in the south east of England during the 1950's. The chart represented data collected from 80 males and 80 females who had been weighed every three months. The small sample size from one specific area of England sheds doubt on how representative the data from this study are of the growth of other infants (Whitehead & Paul, 1984; Freeman et al 1995). The chart failed to show how rapid an infant's growth is initially, with the growth slowing down towards the end of the first year (Wright et al, 1993). It also failed to take into account how different feeding practices can affect weight gain in early infancy.

The World Health Organisation recommended using the National Centre for Health Statistics Standards for the assessment of infant growth (Hammill et al, 1976). These were based upon data collected from the Health Examination survey (1962-70) and the Health and Nutritional Survey 1971-1974. Both sets of data were collected on a child population in the United States. The problem is that the chart is not representative of breast fed infants in Britain (Dewey et al 1992). Also there are cultural differences between British and American children, with the latter being larger in terms of height and weight. A chart of this type would suggest that the incidence of failure to thrive was frequent in Britain, whereas the chart itself is not based upon a representative data set.

A new chart was devised in 1995 specifically for Britain by Freeman et al (1995). The data originated from three different sources. Firstly the Human Measurements Anthropometry and Growth Research Group, collected data from 16 areas in England and Wales. Although this was a good geographical representation, the actual number of infants was small and there was no indication of the gestational age of the infants. The second source of information was The Cambridge Infant Growth Study which provided data on a selection of infants aged 0-32 weeks. This was less representative geographically, since the data were only available for 252 infants aged 4 weeks to 2 years, so there was no data available for the first 4 weeks of life for these infants. Finally, data from the Whittington Hospital London examined 756 infants with a gestational age of 32 weeks. The infants' weight at birth and two days was measured. This chart, however, did not correspond to weight gain in infants in the Newcastle-upon-Tyne area (Wright et al, 1996) or infants in Sheffield (Wales & Kennedy, 1996) and was revised to include a number of centiles above and below the median (Preece, Freeman & Cole, 1996).

The problem with standard growth charts is that when they are used as a comparison on a malnourished population, the data are immediately skewed, with the majority of the population lying on or below the 3rd centile. It has therefore been proposed that SD scores rather than centiles should be used to assess the growth status of infants (Waterlow et al, 1977). An SD score is normally distributed with a mean of 0 and a standard deviation 1, enabling it to be converted to a centile position and vice versa. For example, the mean of 0 is the 50th centile, -1.881 the 3rd centile, and 1.881 the 97th centile (Cole, 1990). The LMS method (Cole, 1990) is an example of how the SD scores can be used to calculate growth curves for a particular population. The growth

curves are created by using a power term (L), to correct for the skew, the median (M) and the standard deviation (S). The LMS method enables smooth centile lines to be created regardless of the distribution of the population.

1.1.2 Threshold based criteria of abnormal growth

Centiles are often used as benchmarks for identifying abnormal growth. Infants below a particular centile line are identified as growing abnormally compared to those above. A number of different centiles are used, and there is no universally agreed centile to use as a threshold. Some studies use the 3rd centile (Wilcox et al, 1989); others use the 5th (Drotar et al, 1990) and some have even used the 10th (Dowdney et al, 1987). Cole (1994) recommended that infants on the 0.4th centile should be hospitalised and those on the 2nd centile should be monitored carefully. The problem with these last criteria is that a large number of small infants would be referred, and the larger infants who have not been gaining any weight, but falling down the chart would be missed, since they had not yet reached the 2nd centile.

These criteria are further complicated because infant growth is prone to fluctuations during the first year. Charts that merely measure infants at 3 month intervals would not be able to take into account the various growth fluctuations that may occur during the first year of life (Whitehead & Paul, 1984). Rapid growth during the period 0-4 months when body weight can double is contrasted with only a 50% increase during the period 4-12 months (Tanner et al 1966b). Weight gain even in the short term can fluctuate especially in males (Giani et al, 1966).

One final problem is that the actual measurements of infants must be standardised. Weight can be measured more objectively than length and head circumference (Drotar et al, 1990). This is because the actual measurement of weight is determined by scales, whereas length and head circumference can be more subjective if not standardised by adequate training. However, in a study of equipment used in health clinics, it was found that the scales were often poorly calibrated, and both imperial and decimal measures were used interchangeably (Davies & Williams, 1983). The infant was often weighed with the clothes on and the weight of the clothes was not taken into account when the final record was made. Also, there were a number of errors made when writing down the dates and weights of the infants on the records. If an infant's weight is not determined accurately, then the appropriate identification of failure to thrive infants is not possible. Therefore, when studying growth in infancy, the procedures must be standardised.

1.1.3 Changes in centile position to identify failure to thrive

Changes in centile position based upon serial weights are often used as a tool for identifying failure to thrive. Serial weights are plotted on a chart that contains the centile markings. The serial weight shows the child's earlier position and their current status. A fall in centile position can be caused by a short term illness. However, a fall that is sustained and crosses two or more major centiles has been used as the criterion for identifying poor growth (Edwards et al, 1990). Edwards used this criterion to identify four different growth patterns in infants. Firstly, early onset, defined as reduced growth that has begun before 6 months of age; late onset, when reduced growth has occurred after 6 months of age; temporary, when there has been a recovery from the

reduced growth; lastly, recurrent, when there are recurring intermittent periods of poor growth.

There are problems with this definition if applied to different populations, particularly when screening for failure to thrive. According to Edwards et al's definition (1990) 20.9% of infants in a deprived area Newcastle upon Tyne had failure to thrive, and 33% in the more affluent areas within the city (Wright, 1995). These figures are compared to the prevalence of failure to thrive identified in other ways as being between 1.3% (Dowdney et al, 1987) and 9.6% (Mitchell et al, 1980). The problem with Edwards et al (1990) definition is that it had poor specificity and often targeted large infants' whose fall in weight was within the norm (Corbett et al 1996).

Davies (1980) argued that very few infants (12%) maintain their centile position for attained weight during the first year. Therefore, the commonly used growth charts showing weight for age, based upon selected samples of infants, are poor indicators of the natural fluctuations in growth during the first year (slow growth, followed by rapid growth and vice versa). How are these infants to be distinguished from those failing to thrive?

Longitudinal measures of growth have confirmed these fluctuations in infant growth (Berkey et al, 1983). It is rare for a child to track along the same centile line without fluctuations. Berkey et al estimated that only 33% of infants between the 50th and 75th centile at three months retained their centile position at one year. About 35% of these infants fall below the 10th centile by one year. In sum, changes in position are very common and using serial weights, and changes in relative position, as diagnostic criteria would be unwise. Infants who drop down centiles may be within normal limits even

though the diagnostic criteria would identify them as cases of failure to thrive (Corbett et al, 1996). Regression to the mean as explained by Cole (1995) suggests that if a group of infants are weighed at two different times, the infants' centile weight appears to have shifted towards the mean. Regression to the mean is a statistical phenomena based upon averages. In relation to weight gain in infancy, it does not mean that all infants will regress to the mean, but the majority will. Therefore if a group of infants were born on the fifth centile, it would be expected that most of these infants will rise above the fifth centile as they mature but there will be some who do not. This leads health professionals to consider actual weight at a certain point in time compared with expected weight as a measure of how an infant is growing. This is described in more detail in the following section.

1.1.4 Identifying failure to thrive using a velocity measure

A Thrive Index (Wright et al, 1994) uses the initial weight of the infant plus their later weight as a tool for identifying failure to thrive. This method was first proposed by Healy (1978) and was later developed as a clinical tool by Wright et al (1994) and Cole (1995). An expected weight for an infant is calculated based upon their previous weight. The formula used is shown below.

$$\text{Expected SDS}_{\text{time2}} = r * \text{SDS}_{\text{time1}}$$

Here r is the correlation between the infants weight at time 1 and time 2 and SDS is the standard deviation or z score. The difference between the infant's actual weight at time

2 and their expected weight at time 2 can be used as an index of failure to thrive. The difference is referred to as the Thrive Index (Wright et al, 1994) as shown below.

$$\text{Thrive Index} = \text{Actual weight SDS} - \text{Expected weight SDS}$$

The Thrive Index is normally distributed, with a mean of 0 and a standard deviation $\sqrt{(1-r^2)}$. When its value is less than 0, the infant has not reached their expected weight for age. A threshold is then determined for failure to thrive over the period six weeks to nine months, 5% of children have a Thrive Index value below $-1.64 * \sqrt{(1-r^2)}$ (Wright et al, 1994).

The Thrive Index provides longitudinal data on the weights of infants essentially comparing them with the mean weight of infants with similar earlier weights. Birth weight can be prone to fluctuations due to intra uterine factors, therefore four to eight weeks weight has been recommended as the baseline measure (Edwards et al, 1990). However, using this age range prevents the very early detection of failure to thrive.

1.1.5 Summarising failure to thrive

There are different approaches towards the identification of failure to thrive. Different researchers use different criteria for the detection of the growth disorder. Some use attained weight others use a change in centile position. The Thrive Index allows for differences in weight gain due to birth weight.

Even when failure to thrive has been detected, there is still little known about why some infants fail to thrive in the absence of an observed organic cause. Furthermore, there is little known about how young infants differ in their feeding behaviour. The following sections address issues concerning factors that have been associated with poor growth in infancy. There will also be a discussion of factors that may enhance growth, feed type, milk composition and the onset of weaning. There is a discussion about the methods generally used to investigate infant feeding and finally an overview of the proposed methods for use in the current study of failure to thrive in young infants.

1.2 Factors that impair infant growth

When an infant is identified as having poor growth, the health professional has to figure out why. A number of factors could be to blame. Is there a physical cause e.g. an illness, and is this illness due to malabsorption or an infection? Is the malabsorption caused by an internal problem or due to incorrectly prepared formula? A history of medical and feeding behaviour needs to be established, and if this contains no indication as to the root cause, then psychological or environmental influences are investigated (Maggioni & Lifshitz, 1995; Chatoor et al, 1997). The feeding context is an important factor that can influence growth (Chatoor et al, 1997). In the study of failure to thrive, the debate continues about whether the infant is inherently difficult to feed, whether the mother is insensitive, or whether there is mismanagement of feeds. One way in which the infant may be the cause is if they are difficult feeders, for example they have problems regulating their sucking, swallowing and breathing thus preventing them from consuming adequate milk (Mathew, 1991a). The differences that are observed in each

of these areas are discussed in the following section along with the appropriate techniques for studying them.

1.2.1 Physiology of sucking behaviour

There are three components of the feeding process: rooting, sucking and swallowing. Rooting, sucking and swallowing all form part of a continuum. Ingram (1962) provides a detailed description of the infant's sucking reflex. The infants' lips are a very sensitive area, and certain involuntary movements are made when a stimulus is placed on or around the lips. The infants lips open and are drawn towards the stimulus, sometimes the head follows, the infant may also swallow and make sucking movements. Certain developmental changes have been noticed (Ingram, 1962). For the first six weeks of life the above mentioned can be observed in the infant. Between 6 and 12 weeks the tongue no longer protrudes in response to the stimulus, the sucking and swallowing also become less frequent, and the infants' head turns one way in response to the stimulus rather than side to side. Ingram (1962) argued that these changes coincide with the infants learning how to breathe more easily. This is a rather curious statement, since breathing is the most natural form of behaviour. Perhaps Ingram is referring to the infant learning how to co-ordinate sucking swallowing and breathing during feeds to optimise feeding efficiency. Even so, this is usually acquired rapidly in normal infants i.e. within the first week (Ramsay & Gisel, 1996).

Mathew (1988) has also written detailed accounts of infant sucking behaviour. The infant initially sucks vigorously and continuously for periods lasting at least thirty seconds, followed by a pause and this behaviour has been termed intermittent sucking

(Mathew, 1988). In order to suck, the facial and labial muscles must contract around the nipple to form a seal. Suction is used to fill the nipple and squeezing extracts the milk. The nipple is compressed against the palate by the tongue (Mathew, 1991a). When extracting milk from the nipple, there are differences in the motions made by breast fed and bottle fed infants. For breast fed infants the tongue appears to roll, but in bottle fed babies the tongue is piston-like. For bottle fed and breast fed infants the milk is taken from the nipple by a squeezing action. The firmness of the nipple and the size of the feeding hole influence the success of the squeezing action (Smith, Erenberg & Nowak, 1988; Bosma, Hepburn, Josell & Baker, 1990; Bu'Lock, Woolridge & Baum, 1990; Smith, Erenberg, Nowak & Franken, 1985).

Wolff (1968) examined the difference between nutritive and non nutritive sucking. Wolff (1968) defines nutritive sucking as: 'any repetitive mouthing activity on a blind nipple other than biting.' Nutritive sucking is defined as 'any repetitive mouthing on a nipple associated with negative intra oral pressure sufficient to deliver a potable liquid from that nipple'. Nutritive is different from non nutritive, as it is a continuous stream of sucking rather than a burst of sucking and a rest. It is also slower rather than faster. Nutritive is noted when milk is available and has a slow steady rhythm. This may be contrasted with non nutritive, when there is no milk and there are short bursts of fast sucking. Non nutritive sucking is often noted towards the end of a breast feed. However, Drewett & Woolridge (1979) argue differently. Although sucking rate increases towards the end of a feed, there is no clear distinction between nutritive and non nutritive feeding. Bowen-Jones et al (1982) also confirm this as both types of sucking were present continuously during breast feeding.

1.2.2 Physiological causes of inefficient sucking behaviour

Halverson (1944 cited in Weber, Woolridge & Baum, 1986) was interested in whether a baby could swallow without having to interrupt breathing. He identified 'good feeders' who are able to inhale, swallow and exhale, while obtaining the maximum food intake with the minimum effort. This is contrasted with poor feeders who are irregular in terms of sucking and swallowing and breathing. Peiper (1961) showed how sucking rhythm dominated the breathing rhythm in healthy infants. He described how the initial breathing rhythm was disrupted by sucking which was faster than the breathing. Within a few seconds the breathing rate adjusted - speeding up to accommodate the demands of the sucking. When a pause occurred after a sucking burst, the rate of breathing was a little unpredictable. However, once sucking finished, the breathing soon returned to its former rhythm.

Ramsay & Gisel (1996) monitored two consecutive feeds soon after birth in both breast and bottle fed infants. The infants were also studied six weeks later. Ramsay and Gisel (1996) found that the sucking efficiency of the infants improved within hours after birth. The bursts of sucking became longer and the amount of time sucking increased. They also found that breast fed infants sucked at a higher rate than bottle fed infants. They also encountered infants who were difficult to feed and, as a consequence, their mothers had taken them off the breast and put them onto bottle feeds, within a few weeks after the birth. They termed this group the 'compensatory', compared to the 'non compensatory' group which consisted of infants who had not had their feed type changed. The sucking behaviour of the compensatory and non compensatory infants was examined after 6 weeks. At 6 weeks, the non compensatory group had almost tripled the duration of their sucking bursts (89s) and doubled the length of time spent

sucking (89%). Although the compensatory group had also tripled the duration of their bursts (47s) and the time spent sucking 69%, their performance was comparable with healthy new born infants rather than their 6 week counterparts. Mothers' reports of their infants' behaviour during the 6 week period showed the compensatory group to consume less per feed but required more feeds sometimes up to 10 per day. Mothers also had to wake their infants for feeds. The non compensatory group had less feeds, consumed more, and were more likely to be awake for feeds.

Why some infants are better at feeding than others may be explained by a variety of factors. For instance, infants with an immature cardiorespiratory system tend to sleep more and their feeds have the characteristics of long pauses followed by short bursts of sucking (Daniels et al, 1988). Another factor could be whether the infant is term or pre term. Some early findings have shown that the age of the pre term infant did not affect sucking but weight did i.e. the heavier the infant the better they were at feeding (Crump, 1958). This has been disputed since more accurate measures of gestational age have been developed, and these do show an effect (Casaer et al, 1982). Despite Crump's estimation of gestational age, he did find that full term infants consumed 0.6cc per second of formula compared to pre term infants who consumed 0.24 cc per second. Casaer et al (1982) not only noticed feeding differences between pre term and term but also behavioural differences. The posture of pre term infants was different, and feeding efficiency was influenced by gestational age.

Both nutritive and non nutritive sucking has been studied in mildly stressed and severely stressed pre term infants (Cowett et al, 1978). These classifications were given according to the number of medical complications. Both groups were also compared to full term infants. The research showed that sucking could be influenced by the type of

fluid delivered. The number of sucking responses increased with increased sweetness. Infants who were severely stressed had impaired sucking ability both nutritively and non nutritively.

A number of other factors affect sucking e.g. barbiturates given to the mother during labour (Kron et al 1968). The sedatives are passed on to the infant via the placenta and can be stored in the infant's tissue for a few days. An ingenious study (Maone et al, 1990) was able to increase the frequency and strength of responses in pre term and term infants by using gelatine based nipples that contained sucrose. The implication of this study could be that infants can be stimulated to increase their intake by altering the sweetness of milk.

1.2.3 Oral motor dysfunction

An efficient feeder can co-ordinate the mechanisms of successful feeding i.e. sucking, swallowing, breathing and ingestion in order to grow normally. The inefficient feeder has trouble with one or more of these factors thus impairing growth; this is referred to as oral motor dysfunction. Suggested causes have been neurological dysfunction, or delayed introduction of solids (Hepstinal et al, 1987, Illingworth & Lister, 1964).

Lewis (1982 cited in Skuse 1989) identified several oral motor dysfunctions that may occur in early failure to thrive cases, these were sucking, swallowing and breathing, tongue thrusting, biting, excessive drooling and intolerance of developmentally appropriate textures. Hepstinal et al (1987) reported that infants who were failing to thrive were introduced to solids at around five 1/2 months, compared to controls who

were introduced at four months. Similarly, independent feeding did not occur in infants who were failing to thrive until five months after the controls had acquired this skill (Hepstinal et al, 1987). Illingworth & Lister (1964) observed oral motor problems ranging from an inability to chew, spitting or drooling foods to food refusal in a number of clinical case histories. The problem with these children was that they were not introduced to solids until the time of admission to hospital. The cases ranged from one to four years of age. All children had received late introduction to thickened feeds as infants, and had not been introduced to solid food until their admission to hospital. Illingworth and Lister (1964) argued that there was a sensitive period for the introduction of solids. He based his theory upon studies of critical periods in animals and of case histories of human infants, who either had an organic cause for delayed introduction of solids (e.g. hiatus hernia) or because care givers had simply withheld solid foods. In sum, the case histories suggested that if weaning was not introduced at the appropriate time, feeding difficulties developed. The infants refused solids and appeared to have poor chewing ability. Illingworth and Lister suggested that the delayed introduction of solids (after seven months) resulted in an inability to chew, refusal of solids and vomiting. He wished to draw a distinction between solids and thickened feeds, which are introduced at around three months. Why parents choose to withhold solid food remains to be answered. An inability to chew and vomiting may be considered examples of oral motor dysfunction since the infant does not have the capability to chew the food correctly and swallow appropriately without gagging. The origins of these oral motor problems and food refusal are evident in early infancy, and if they are not addressed effectively, the infant will not gain weight and thrive.

A number of chronological studies by Dahl (1987) and Dahl and Kristiansson (1987) have indicated that feeding problems identified in early infancy continue in early

childhood. Dahl's first phase of investigation involved recruiting 42 infants with feeding problems. These feeding problems were on average encountered around the age of two to three months. The observed feeding problems were a) refusal to eat (RTE); b) recurring colic and c) vomiting. Each of these cases were matched with controls in terms of district, age and sex. At the age of two years, evidence of RTE remained, but colic had disappeared and vomiting had been greatly reduced. The two year olds, who still had feeding problems, also appeared to have more infections and behavioural problems than controls.

Reilly & Skuse (1993) recorded 25% of children who fail to thrive for no organic reason having motor problems similar to infants with cerebral palsy. Wishon et al (1968) reported that failure to thrive infants have poor eye contact, delay in fine and gross motor development, food refusal, extreme passivity, excessive sleep, spitting up and vomiting, irritability, diarrhoea, minimal smiling, unusual watchfulness, lethargy, abnormal persistence of infantile posture, hypertonicity and self stimulating play. It is difficult to determine which comes first, the behavioural problem or the feeding problem.

Dahl and Sundelin (1992) also noted in children who refuse to eat that birth weight and length was lower in cases than controls. When the onset of RTE was identified the growth faltered and there was no evidence of 'catch up' at two years. Although at two years the RTE cases were within the normal range, they were shorter and lighter than controls. At the age of four years, the number of health problems (i.e. infections) in RTE had decreased and an increase in weight had occurred. However, the behavioural problems persist, with some children described as hyperactive by their mothers. In sum, the feeding and behavioural problems appeared to remain.

A number of different scales or checklists have been developed to investigate oral motor problems in infancy. They provide a checklist for experimenters to code an infant's feeding behaviour from video tapes of feeds. The scales are designed to investigate how an infants responds to different food textures. The procedure usually involves presenting the foods and coding tapes of the feeds afterwards. By using these scales differences between cases and controls can be identified and summarised to provide a description of how case and control infants respond to different textures. The Neonatal Oral Motor Assessment Scale (NOMAS) (Palmer, Crawley & Blanco, 1993) has 13 characteristics of jaw movement and 13 characteristics of tongue movement that are subdivided into normal, disorganised and dysfunctional categories. The scale works by an examiner observing an infant being fed during a normal feeding episode. The examiner must make a judgement as to whether the jaw and tongue movements made by the infant match the behavioural criteria of the scale. For example, a 'consistent' or 'inconsistent' sucking pattern. In a reliability study of this scale 17 of the 26 categories had 80% reliability across examiners. However, in one category, 'inconsistent jaw depression'; reliability was only 63% of the time. The scale provides a lot of descriptive feeding behaviour about the infants, but more adequate training of the examiners is needed. Since the reliability study was carried out on healthy full term infants, there is research potential to examine reliability studies of infants who were failing to thrive. The studies of case and control infants would have to be carried out blind, in order to eliminate bias in the coding of the infants' behaviour.

The Feeding Assessment Schedule (FAS) can be used to summarise oral motor feeding problems in infants (Mathisen et al, 1989). The FAS was used to assess the frequency of oral motor problems in twelve month old cases and controls. A study of both groups

was carried out by an experimenter blind to the child's group. To administer the FAS the experimenter presented the infant with a variety of solids that had different textures. The feed was video recorded and later coded by the experimenter using the FAS checklist. Normal and abnormal behaviour in response to the different textures was obtained by determining what other researchers had discovered was either abnormal for the age of the infant or normal for a neurologically sound infant of that age. Mathisen et al (1989) concluded that the oral motor function of failure to thrive infants was developmentally delayed. On all of the food textures presented, the failure to thrive infants were poorer than controls.

The FAS was used in a subsequent study (Mathisen et al, 1992) to investigate oral motor problems in infants with Turner Syndrome. Turner Syndrome is associated with high palate, mildly nasal speech, small jaw and crowding of teeth. Its prevalence is between one in 2000 and one in 5000 live born females. Mathisen et al used the FAS to investigate a group of case and control infants aged between six and 29 months. They found that infants with the syndrome had a higher incidence of oral motor problems than controls. The infants with Turner Syndrome also had poor growth.

Reilly et al (1999) developed the Schedule for Oral Motor Assessment (SOMA). This is very like the NOMAS outlined above, in that it entailed the direct observation of infant feeding behaviour by a trainer examiner. The SOMA required a rating to be given about how well the infant responded to the standardised presentation of various tastes and textures. These included puree, semisolids and solids. The solid category had two components, one that required spooning and the other that required biting and chewing, e.g. biscuits/crackers. Each component of the infant's behaviour during the feeding episode i.e. orientating towards the food, accepting the spoon, sucking, chewing

etc, was listed on the SOMA. The examiner gave a 'yes/no' response for each component. Therefore, a child with oral motor problems would not accept the spoon properly, would be unable to chew etc; and the examiner would rate those particular components of the feeding episode negatively. Reilly et al (1999) found that infants who were failing to thrive scored above average for all these categories i.e. puree, semisolid and solid.

Although this may be considered a significant finding, there were some problems with this study. The infants used in the study had failed to thrive during the first year of life. However, little detail is provided on what point during the first year did the infants fail to thrive. Was it around four months when infants are introduced to semisolid foods, or were the infants faltering in growth before this point? Furthermore, the study did not have a control group of normally growing infants. It is therefore unclear as to what comparison group the authors compare their results to when they claim that infants who were failing to thrive scored above average on all three categories of foods.

The scale itself cannot be used to study liquid feeds, therefore eliminating it as a possible measure of oral motor problems in milk fed infants. Another problem is that the observation of feeds did not appear to be carried out blind. The authors took additional measures including an interview with the primary caregiver that was conducted on the same day, prior to the observation of the infants' feeding behaviour. It is possible, that this may have influenced the interpretation of certain behaviours during the feeding episode.

A validation study was carried out using the SOMA (Skuse et al, 1995) on 127 infants aged between eight and 24 months. Of these 127 infants, 56 had failure to thrive, 13

had cerebral palsy and 58 were controls. The study involved the test to be run three times with each infant with the caregiver and the third time the infant was allowed to self feed. Skuse et al found that the failure to thrive infants had a higher incidence of abnormal oral motor behaviours than control infants. The infants with cerebral palsy had higher incidence of oral motor problems than the failure to thrive infants. The results also showed good inter reliability and validity. However, despite the positive nature of the results, it does not tell us a great deal about failure to thrive in early infancy i.e. prior to solids. Furthermore, although infants who were failing to thrive and control infants were used, the research does not tell us for how long the failure to thrive infants had been failing. One obvious question to ask is, do infants who are failing to thrive who also have long term poor growth differ from those with later onset of failure to thrive? For example do infants with sustained failure to thrive display more acute oral motor problems than infants that have only recently become cases.

1.2.4 The origins of feeding disorders in infancy

The origins of feeding disorders in infants are difficult to pinpoint. Benoit (1993) estimated that between 1-5% of all paediatric hospital admissions infants failing to thrive and 39% of infants with developmental disabilities experience feeding problems (Reilly et al, 1995). These feeding problems can be very resistant to change and can be identified in early childhood as various follow up studies have noted (Dahl, 1987; Dahl & Sundelin, 1992). These early feeding problems are risk factors for adolescents developing anorexia nervosa or bulimia nervosa (Marchi & Cohen, 1990). They are a result of an interaction between biological, interpersonal and social factors. There are

very few studies that have detailed records of specific feeding behaviours of infants who fail to thrive.

One theory is that infants who fail to thrive do not consume enough energy to allow normal growth; however the research concerning this has mixed results. In a study of case and control infants that were fed solids, case infants were found to spend significantly less time feeding than controls (Mathisen et al, 1989). Gremese et al (1998) compared 43 healthy controls, 53 diseased controls and 12 non organic failure to thrive infants and 20 infants with failure to imbibe. The failure to imbibe group took significantly longer to feed than the other groups (mean = 41 minutes); they also consumed less milk (mean = 92 ml). Interestingly the non organic failure to thrive group were the next most inefficient feeders; they also took longer (mean = 15 minutes) and consumed less milk (mean = 130 ml) than controls and diseased controls. This suggests that they perhaps do not consume enough milk to enable them to gain weight. One reason may be that they spend longer sucking non nutritively, or perhaps they tire very easily, or perhaps they are not offered enough milk. Looking at the specific sucking behaviours of these infants during the course of the feed would therefore be very useful. Some intervention studies have found that increasing energy intake promotes weight gain (Tolia, 1995, Schaffer-Bell & Woolston, 1985). When infants were weaned off high energy supplements, weight loss resumed (Tolia, 1995).

Inadequate intake may be the result of inadequate access to food or inadequate food acceptance. Some infants have reportedly had no interest in food from early infancy (Schaffer-Bell & Woolston, 1985). Inadequate intake has been attributed to an interaction problem between infant and caregiver during feeding (Chatoor & Egan, 1983; Powell, 1988; Chatoor et al, 1998; Chatoor et al, 1997). Other reasons for

inadequate intake are the infants' temperament, an impoverished or stressful environment and poor feeding interactions between infant and caregiver (Rathburn & Peterson, 1987). However, comparing slow growing and control children Hepstinall et al (1987) did not find any significant difference in the quantity consumed or the duration of meals. Instead the authors noticed that the cases and controls differed on familial characteristics associated with mealtime behaviour. For example case infants were more likely to experience a hostile environment during meal times, often eating without supervision and with angry interactions with other family members. Hepstinall et al found that mothers of case infants reported that mealtime behaviour had been a problem since early infancy, but the authors admit that the mechanisms that transfer negative interactions into poor growth are unclear. Other research has also found that mothers have reported problems originating in early infancy (Tolia, 1995).

Whether the mother or the infant is the source of the problem is unclear. What does appear plausible is that there is a series of poor interactions between mother and infant. Clearly there can be a series of miscommunications between mother and infant, some of which can originate in early infancy. For example the mother can impose a series of rules at feed times based upon her own expectations. For example, feeding the infant on a schedule rather than demand may have long term effects (Wright et al, 1980). In a study by Wright et al (1980) it was found that bottle fed infants were often given the same quantity at each feed, despite the long interval and their own hunger. Breast fed infants were able to consume more to compensate for the longer intervals. The long term effects of this learning may help explain feeding problems that occur in later infancy, although research would have to be conducted to investigate this. Wright has also found that the size of the infants' meal differs according to the time of day. At two months of age, the largest meals are those that occur at the beginning of the day

following an overnight fast. By four to six months, the largest meals are often those at the end of the day, preceding the overnight fast. Perhaps the infant anticipates the overnight fast and therefore consumes a larger meal (Wright, 1986). At four weeks of age meal size remains constant throughout the day. The mother may not be aware that these differences in intake are normal, and may try and introduce more or less milk to satisfy her own expectations. These will in turn alter the infant's feeding experience.

Research has indicated that the behaviour of infants with failure to thrive is often described less favourably. Mothers of case infants have reported that the infants are not able to communicate about their needs during mealtimes. For example the mother is unsure if the infant has had enough to eat, or whether they want to eat faster or slower. Mothers also report that the infants' are not particularly sociable during mealtimes and do not really participate in normal interactions (Mathisen et al, 1989). Temperament has also been associated with maternal sensitivity. Hagekull et al (1997) found that infant temperament and maternal sensitivity were associated with the development of early feeding problems. Maternal sensitivity was measured using attachment principles. Through a series of interactions at six weeks, four months and ten months, the mother's ability to respond to infant's social signals; warmth and physical contact with the infant etc, were recorded. Temperament was measured through questionnaires given to mothers that asked them to provide information about how the infant coped in everyday situations. The research showed that infants aged ten months and followed up at two years, the stability of their feeding problems was correlated with the less sensitive mother and the more troublesome infant. In another study of case and control infants aged nine to 19 months, maternal physical interaction and affection were reduced in mothers of case infants (Polan & Ward, 1994). The main problem with this study was that the experimenters were not blind to the status of the infants, they had access to the

clinical reports. The study also examined the mother's sensitivity and did not take into account the role of the father or other primary caregivers. The authors were unsure about how maternal insensitivity manifested itself into failure to thrive in infancy. It could be possible that they are separate issues. The authors suggest that future research would have to explore maternal sensitivity and infant behaviour at mealtimes and during play to determine if the mother is adverse to physical contact or whether the infant has reduced ability to feed properly.

A stressful feeding context can lead to the infant becoming troublesome as a means of trying to take control. The noisy, often chaotic feeding context is another potential area that has been targeted as the source of poor eating behaviours. In an ideal situation, the infant might be seated in a highchair at the dining table with the other family members. The atmosphere would be relaxed and sociable. Studies comparing the mealtime environment of children who fail to thrive and controls have found some differences. It has been reported that case infants often sit in the living room during mealtimes where there is excessive noise and movement distracting them from their meal, whereas control infants were often fed in the kitchen or lounge (Mathisen et al, 1989). Mothers of case infants were also less likely to use a high chair. Case infants often stood at a low table or baby walker or lay on the mother's lap.

In extreme cases, the infant can become so adverse to mealtimes that they refuse to eat. Refusal to eat has been identified as the main behavioural characteristic of infants with infantile anorexia (Chatoor et al, 1997). This disorder may be associated with failure to thrive. There is a great deal of debate over the behavioural classification system of the various feeding disorders. Different authors use different terminology to describe similar behaviours observed in infants. Failure to thrive is often used as a diagnostic

label, but not all infants with failure to thrive have feeding problems. They appear to feed normally but their growth is poor. This may explain why case and control infants consume the same quantity, but the cases fail to grow normally. Similarly, infants with feeding problems do not always show poor growth.

Chatoor et al (1997) proposed that infantile anorexia developed through a series of caregiver and infant interactions. The infant's temperament evokes conflict over control between mother and infant. The interactions become increasingly negative particularly at meal times. Chatoor et al (1997) suggest that the infant's eating becomes controlled externally through these negative interactions rather than internally through their own mechanisms of hunger and satiety.

Chatoor et al (1997) identified the weaning process as the point when infantile anorexia can develop. This is an important stage in the infant's development, when they must learn to become more independent and learn the skills of self feeding. Chatoor et al (1997) suggest that the mother must be sensitive to the infant's behaviour. If the infant's behaviour is misinterpreted, and they are forced to consume more than they physically require the infant will subsequently confuse their own physiological feelings with the emotions experienced while feeding. They will learn that their intake is controlled externally, especially through emotions displayed at meal times. It is in a series of interactions between caregiver and infant that the foundations for infantile anorexia are developed.

The theory appears plausible, and Chatoor et al (1997) have clearly taken a behavioural analytic perspective on the aetiology and their proposed treatment. However, if they are looking at the behavioural history of the infant for clues about the origins of the

disorder, then they must also respect whether the mother has coped (or not coped) with interpreting her infant's behaviour when the infant was exclusively milk fed. This will be discussed in depth in a later section when the mother's role during feeds is addressed. The mother must have poorly interpreted her infant's behaviour at this early stage. Recent studies (Wolf & Glass, 1992) have indicated that these feeding problems may be evident from birth as mothers of infants with feeding problems report that their infants were more interested in looking around than getting on with the feed. However, the anorexic element does not manifest itself until the infant becomes mobile and is more interested in exploring than feeding. Another problem with the theory, is that it is possible that if an infant is offered food as a soother for their negative emotions, the infant will display the emotions more frequently in order to receive more food. A learning history of this nature would surely make the infant prone to obesity. This alternative possibility is not addressed by Chatoor et al.

The infants' temperament can also be a factor determining the nature of the feeds. Infants with feeding problems are often described as moody with a low threshold for stimulation (Carey & McDevitt, 1978). Chatoor suggests that these infants are so easily distracted that their own physiological signals are difficult to focus on. The origins of temperament or indeed personality are debatable. If a behavioural analytic view is taken of temperament, the infant may have experienced a history of crying continuously before being fed during the months prior to weaning. Perhaps the mother misinterpreted their need for more milk and their frustration has been conditioned to occur in the presence of subsequent feeds. Chatoor et al (1997) argues that a temperamental older infant will use their behaviour as a control mechanism.

This is a rather curious proposition since the theories presented for the origins of infantile anorexia are all based on behavioural principles of classical conditioning. That is the infant has been conditioned that their frustration is paired with food being offered. Chatoor is implying that something new has been acquired by the two year old infant. In behaviour analytic terms the child may have basic verbal regulation and rule governed behaviour that a younger infant would not have, but this is very rudimentary and is not as sophisticated as in the school aged child. Is some new behavioural principle learnt by school aged children to explain the incidence of childhood anorexia? Why is childhood anorexia any different from infantile anorexia, when the diagnostic criteria are the same?

Treatment for anorexic infants appears to rely heavily upon behaviour modification techniques. Chatoor et al (1997) suggests a way of initiating the infant to respond to their own physiological need. This is achieved by only offering food at meal times, in the absence of any other distracters in the home (e.g. television). The child is given small portions with the option of asking for more. This is to help the child develop the sensations of hunger and satiety. Other behavioural principles are used to deal with the infants' temperament for example reinforcing appropriate behaviour. This implies that temperament can be shaped by the environment, suggesting that a closer examination of the management of feeds in early infancy may explain the origins of temperament in the older infant.

Effective treatment is dependent upon early identification, which however, can be difficult. Chatoor et al (1997) suggest that if the disorder is not rectified then social, cognitive and behavioural changes may result. The infant may become more unresponsive, irritable and lethargic. Less energy means the infant will be less likely to

explore their environment leading to developmental delay (Ricciuti, 1993). The infant may sleep longer in an effort to conserve energy, which restricts their opportunities to feed (Moores, 1997).

1.2.5 Internal regulatory problem

Poor growth can also be caused by an inadequate intake of energy (Frank & Zeisel, 1988). Internal regulation can be influenced by nongastrointestinal and gastrointestinal problems. Gastrointestinal problems such as malabsorption can cause poor weight gain. Symptoms of malabsorption include, diarrhea, flatulence and cramps. Substituting the missing enzyme to alleviate the problem is usually recommended or eliminating a particular food from the diet. Neural, hormonal, psychological and environmental influences can all interact to cause poor growth. The nature of the interaction is poorly understood, and research points to risk factors, implying that the more of these that are present, the greater the risk of poor growth.

The mechanisms that control hunger and satiety lie in a collection of cells within the hypothalamus. One set of cells, if stimulated induce hunger, and the other set satiety. A number of chemicals can stimulate this area including insulin and the hormone cholecystokinin (CCK) (Le Magnen, 1985). The amount of body fat also influences the sensitivity of this area to insulin, for example, a person with high adiposity may be less sensitive to insulin. It is possible that people with low adiposity may be highly sensitive to insulin (Leibowitz et al, 1988). There are nongastrointestinal influences on growth, these include hormonal and neurological factors. Blood sugar plays an important role, it rises after a meal signalling the release of insulin which helps cells absorb the sugar.

When the blood glucose lowers, hormones are released into the blood stream causing the cells to release sugar in order to reach equilibrium. If there is a failure to produce insulin or the cells fail to respond to the hormones, the result is diabetes. Excess sugar and calories are flushed out of the body in the urine, and the patient loses weight.

Specific growth hormones such as thyroid and glucocorticoids can affect physical development. Thyroid helps to regulate the metabolic rate; over production can lead to weight loss, heart palpitations and overactivity. Often the symptoms can be more subtle and the condition may be overlooked for long periods; it is therefore possible that they may lie undetected in infants. Glucocorticoids affect the body's response to stress and production failure can lead to Addison disease.

If an infant has a cardiovascular and/or respiratory system problem, growth will be affected. Problems with these systems requires more fuel to help the body function and this can lead to weight loss or failure to gain weight. Other factors such as emotions may influence the control of appetite. But these are complicated and poorly understood. Depression may induce a loss of appetite but it may well stimulate the appetite as well. Malnutrition can cause biochemical, endocrinological, immunological gastrointestinal and central nervous system alterations.

Prenatal and postnatal factors can also affect growth. Prenatal influences can be genetic i.e. Down syndrome or Turner syndrome; or non genetic i.e. a result of substance abuse that impairs interuterine growth. Other factors include prescription drugs, maternal infections such as Rubella, chickenpox and cytomegalovirus. A reoccurring theme within infant nutrition is the notion of a critical period in which there is an opportunity to experience certain things that may affect long term feeding behaviour. One example is

that there may be a critical period during pregnancy when poor nutrition permanently alters the growth of the body and brain of the foetus. Certainly prolonged growth retardation results in smaller children, and a number of studies have recorded this pre growth occurring in the second half of the pregnancy. As brain growth is rapid during this intrauterine period, the foetus may be vulnerable to long term developmental programme. Widdowson & McCance (1975) suggest that since the appetite centre lies in the hypothalamus which organises the rate of growth, under nutrition at this time results in a smaller appetite, thus giving rise to a smaller body size. Dormer and Staudt dispute this, as the hypothalamus develops between the fourth and seventh month, and growth retardation is likely to occur after this period. If we are looking for an internal regulatory explanation for the feeding behaviour of an infant, examining animal models of appetite may be useful. Postnatal factors include reoccurring infections, where the immune system requires so much more energy to combat them. Food intake usually drops during an illness and increases thereafter. Under nutrition can lead to an immature immune system and this in turn leads to more infections, creating a vicious circle.

Thermoregulatory feeding links body temperature with energy intake (Himms-Hagen, 1995a). Thermogenesis is the metabolisation of brown adipose tissue in reponse to a dip in blood glucose level (Tapp, Levin & Natelson, 1981; Vallerand, Persusse, Buckowieki, 1987; Vallerand, Persusse & Berkowieki, 1990; De Vries, Stubbe, Wildring, Gorter, Prins, 1993; Campfield, Brandon & Smith, 1985; Campfield & Smith, 1986; Campfield, 1990). Thermogenesis causes a small rise in body temperature, the animal begins to feed and termination of feeding is triggered once the animal has attained a certain body temperature due to brown adipose tissue thermogenesis (Himms-Hagen, 1995a). Once body temperature has risen, sympathetic nervous system (SNS)

activity (SNS) decreases and thermogenesis is terminated. This in turn signals the end of a feeding episode. The body temperature does not rise any further, but slowly declines again until the level that activates the SNS is again reached, and the feeding episode is triggered once more. The time spent feeding depends upon the ability to increase body temperature by thermogenesis. Therefore, the amount of food consumed is said to be dependent upon thermogenesis and on ambient temperature i.e. a cold environment requires brown adipose tissue production and increased food intake. Himms-Hagen (1995a) suggests that this may explain the occurrence of obesity in animals: once an animal fails to adjust its intake according to its thermoregulatory needs the meal size is increased.

Applying the work conducted on rats to the feeding cycle observed in human infants is possible only if similar behaviours can be observed and recorded in humans as in rats. Such observations in human infants are limited. There is limited research available on the effect of ambient temperature on human infant feeding. Elder (1970) conducted a piece of research that investigated the effect of ambient temperature on infant feeding. This was achieved by heating the crib in which the infant lay whilst being fed. Elder found that sucking pressure in infants decreased as ambient temperature increased. Elder also found that sucking pressure in the morning was higher than in the afternoon. The researcher did not consider what effects these circumstances would have on feeding (i.e. whether more milk is consumed at a particular time of day). Elder failed to take baseline measures of sucking pressures and there was no consideration given to the time elapsed since the previous meal. Both of these factors may have affected the conclusions reached. Wailoo, Petersen & Whitaker (1990) investigated disturbed nights in 3 to 4 month old infants. The researchers found that it was often a warmer infant, i.e. those wrapped in significantly more clothing and sleeping in a warmer environment,

disturbed their parents during the night. The parents may offer the infant food, or they may settle the infant by some other means. The effect of feeding on the infant that was already warmer than the infants who remained sleeping was to cause the body temperature to rise further. For the infants who were not fed, rectal temperature decreased within 30 minutes. This does not fit the pattern of thermoregulatory feeding, whereby body temperature drops prior to feeding and rises once feeding commences. There are a great number of methodological problems that prevent adequate investigation of temperature change and feeding in infants. One study may not be directly compared with another study since the experimental environment may differ. A number of factors may influence the results obtained: familiarity of experimental surroundings, the type of apparatus used around the face and head; the level of noise/light; whether there are any drugs administered to the infant either directly or indirectly (i.e. through the mother's milk). The infant's activity level affects the rate of heat production. It is therefore important that the techniques used are as unobtrusive as possible. Environmental temperature also has an effect on heat production, a fact that was often neglected in early studies (Sinclair, 1979).

Himms-Hagen (1995a) argues that there is a strong case for a link between temperature and feeding in infants. The presence of brown adipose tissue and its thermogenic qualities, together with the research into infant body temperature, present a strong case for thermoregulatory feeding. The theory provides a means of characterising the survival strategies of new-born infants. Through crying the infant communicates the need to be fed. The role of brown adipose tissue is therefore not just to act as a furnace, but ensures that the infant is fed at regular intervals. The mother's response and choice of feed add to the complex nature of feeding. If the infant's growth could be related to their own internal regulation, it could be reasoned that it is a thermoregulatory

dysfunction. It is possible that a failure to thrive infant experiences less temperature fluctuations than a normal infant, or that their body temperature rises faster than that of a normal infant during feeds; thus their feeding episode would be shorter than those of a normal infant. This could be a neat way of explaining non organic failure to thrive, reasoning that it has merely been termed non organic because the temperature of the infants has not been investigated. In the absence of further research, however, thermoregulatory feeding will remain an animal model of feeding behaviour.

The concept of thermoregulatory feeding may, however, have implications for the care and nutrition of infants. Firstly, feeding on demand, as opposed to feeding on a schedule, may be more complementary to the infants' energy needs. Secondly, investigating the daily feeding behaviour of infants who were failing to thrive and controls may give some indication of regulatory problems. Fullard et al (1984) recorded an absence of a daily rhythm in infants who fail to thrive; they appeared to have no regular routine. Whether there would be physiological differences compared to controls that would explain this would need to be investigated. A record of their sleeping and feeding behaviour would give some initial indication. A failure of thermoregulatory feeding may be a result of a lack of normal brown adipose tissue levels that signal arousal and feeding.

1.2.6 Environmental factors that impair growth

Historically, the social environment of a non organic failure to thrive has been associated with poverty and neglect. Chapin (1908) described how the infants that were admitted to hospital would be returning to impoverished environments upon their

discharge. He argued that the poor growth of these infants was due primarily to malnutrition, and proposed that the recovery of these infants was dependent upon an altered environment with good primary care and proper hygiene. The solution appeared to be removing these infants from their current homes and placing them into enriched environments. Growth failure was firstly associated with emotional deprivation in children living in institutions, where death rates were particularly high. In one study of 11 institutions caring for infants, the death rate was 42% for children under the age of two years (Chapin, 1915). Spitz (1945) argues that it was the lack of emotional stimulation and individual nurturing, rather than nutritional deprivation, that was the cause of the problem. Growth failure was secondary to emotional deprivation. Spitz (1946) investigated this further, and discovered that even if institutionalised infants were placed into enriched environments, they did not recover. The infants were retarded mentally and their growth did not recover i.e. the children were smaller and lighter than normal. Spitz argued that the first year of an infant's life was vitally important to the health of the child in later life. He identified maternal absence and lack of stimulation during the first year of life as the cause of later psychosomatic problems. Follow up studies of older children who had suffered from failure to thrive as infants discovered that the children were mentally retarded and emotionally disturbed, and the families were dysfunctional (Glaser, 1968). The hospitalisation of infants provided an opportunity for clinicians to distinguish between organic and non organic failure to thrive. If an infant did not recover whilst in hospital, the reason for their poor growth was labelled organic. If, on the other hand, the infant did recover, the label of non organic was given, and a poor home environment was viewed as the cause. As a result of these studies, the proposal that failure to thrive was a deprivation issue, resulting from poverty and inadequate infant-mother attachment, was formed. The problem with these early studies was that they were based upon hospitalised infants, in other words

the extreme cases were used as a basis for developing theories about infant growth. Another was a general lack of understanding about growth disorders. For example, a distinction between organic and non organic causes of failure to thrive. Removing an infant to hospital is perhaps not the solution, since it takes between two and three weeks for any sign of recovery despite the provision of adequate calories (Oates & Yu, 1971). There may have been a social issue in the demographic characteristics of these referrals. It may be the case, that the only infants that were referred came from impoverished homes, as these were viewed as more vulnerable than infants from more affluent homes. Consequently, the infants who were examined during hospitalisation were not representative of all failure to thrive cases.

Research has investigated the social environment of infants who fail to thrive to determine whether they differ from that of controls. Frequently, the homes of children who fail to thrive are impoverished or overcrowded (Dubowitz, 1989) with no extended family or lack of social support (Bithoney & Newberger, 1987; Bithoney & Rathbun, 1983; Pollitt & Leibel, 1980). Other studies have indicated that poor intra familial relationships, particularly marital, are more common in the homes of infants that were failing to thrive (Belsky et al, 1984).

The role of the primary caregiver is demanding. The mother is typically the primary carer for the new born infant. She needs to be able to discriminate between a hungry infant and an infant that is in distress. Research has examined how the mother learns to make such discriminations (Wright, 1986, 1987). This is important because early feeding processes impact upon a variety of behaviours including sleeping patterns in early childhood (Beal, 1969; Bernal & Richards, 1970; Bernal, 1973; Blurton-Jones et al, 1978; Campbell, 1958); and obesity and other eating disorders in later life (Bruch,

1974; Martin, 1978; McIntosh, 1985; Shulka et al, 1972; Taiz, 1983; Wright, 1981; Wright, 1982).

Mothers who breast feed their infants unlike bottle feeds cannot determine how much milk their infant has consumed. Wright (1986) investigated mothers who breast fed their infants to determine how accurate their assessments of their infants hunger was. What was striking was that mothers differed in their descriptions depending upon the sex of the infant. Mothers of all 14 male infants stated their hunger varied across the day, compared to 9 females described similarly, and 7 females described as no different. Mothers of male infants reported the frequency of feeds in relation to the time of day, whereas mothers of female infants reported crying and agitation as a sign of feeding. Most of the mothers of male infants targeted late afternoons/early evening as the time when their infants were most hungry, compared with only a quarter of the mothers of female infants. Very few mothers of either male or female infants accurately described a time of day when they had less milk available. In terms of how accurate these assessments were, it was found that mothers of female infants scored correctly 63% of occasions compared to 30% for male infants. Another interesting point is the type of behaviour noted by mothers of male and female infants. Females were more likely to be described as frequent feeders requiring feeds up to every three hours, whereas males were more likely to be described as crying or screaming until they have finished a feed. Females were more likely to be hungry in the late afternoon/early evening, male infants were described as hungry in the late afternoon and early morning. Again, this study found that mothers of female infants were more likely to correctly identify hunger than mothers of male infants. The research suggests that mothers of female infants were more sensitive to their infants than mothers of male infants. The mothers who scored poorly may improve in their ability to make more accurate assessments as they become

more experienced. Wright did not specify whether the infants were first born or second born, a factor that may explain why some mothers performed better than others.

This research does suggest that mothers may interpret the behaviour of an infant differently, depending on whether it is a boy or a girl. Korner (1973) found that female infants were more likely to engage in hand to mouth activity before and after a meal. These behaviours associated with hunger may be more apparent to mothers of female infants, leading to greater awareness in the mother about how hungry her infant is, as found by Wright (1986).

All of the research reported so far has focussed upon mothers of normal growing healthy infants. In the area of failure to thrive, the characteristics of the mother come under close scrutiny. These may be broadly categorised as those specific to the feeding episode, or more general characteristics. The way in which a mother behaves towards her infant during the feeding episode can help identify problems. However, because the feeding context involves a series of interactions between mother and infant, it can be difficult to identify who is causing which reciprocated behaviour. A series of check lists have been developed to record the occurrence of key behaviours. Examples are the Chatoor Feeding Scale (Chatoor, 1984); the test of Sensory Function in Infants (Degangi & Greenpine, 1989); the Infant/Toddler Symptom Checklist (Degangi et al, 1995) and the Home Observation for Measurement of the Environment (Caldwell & Bradley, 1984).

Studying the feeding context entails looking at many different things. A feeding diary is a record of what is consumed, when it is consumed and how much is consumed. The problem with feeding diaries is accuracy. How can the researcher be sure that the

information that is given is accurate? The researcher may consider using additional measures which are taken in the home during mealtimes. Observations that can be made are numerous and include the location of the meal, seating arrangements, number of people present, the time of the last meal, type of food offered and the behaviour of the person feeding the infant. Observing multiple interactions like these can reveal a lot about how feeding problems occur. Observing the interaction between caregiver and infant enables the researcher to look at the management of the feeds and the responses made between infant and caregiver. Specific measures could include the following: How does the feeder react when the infant refuses food or spits food out? Does the infant attempt to feed itself or give behaviours that signify they need more? Is the infant encouraged in any way? There are different ways of collating this information, from informal notes to structured observations requiring coding systems. There are different coding systems designed to record behaviour, some for pre weaning and others for post weaning. Sucking can be recorded by taking a video recording of the feed and recording each suck (Woolridge & Drewett, 1986). Alternatively, sucking can be measured more directly using transducers that enable the recording of pressure changes during bottle feeds (DeMonterice et al, 1992). After weaning coding systems would record how often the infant accepts, refuses, spits, swallows, leaves the table, plays with food or cries, as for example, in the Neonatal Oral Motor Assessment Scale (NOMAS) used by Palmer et al (1993). Other coding systems record the feeders behaviour e.g. positive and negative behaviours displayed towards the infant during mealtimes, as in the Schedule for Oral Motor Assessment (SOMA) used by Reilly et al (1999). Both of these were reviewed earlier in relation to the discussion on oral motor dysfunction.

Maternal characteristics have been focussed upon as the primary cause of feeding problems. Failure to thrive has been described as a relationship disorder between infant

and caregiver (Beniot et al, 1989); or a disturbed mother infant relationship (Berkowitz & Senter, 1987) or associated with a higher frequency of deficiencies in maternal interaction behaviour (Drotar et al., 1990). These studies associate failure to thrive with certain maternal behaviours. In Benoit et al (1989) mothers of case infants were found to be insecurely attached, with a history of unresolved bereavement, lack of social support and a poor current relationship with their partner. Mothers of case infants were also noted to express fewer vocalisations during play with their infants, they were less likely to soothe or cuddle the infant.

The problem with these studies is that they are conducted on infants of six months (Drotar et al, 1990), 12-18 months (Berkowitz & Senter, 1987), or five years (Benoit et al, 1989). There is no indication as to whether the interaction problems develop as a result of the infants developing failure to thrive or whether the interaction causes the infant to develop failure to thrive. The former would appear a more reasonable argument since it is difficult to explain how attachment/interaction measured during play relates to the feeding behaviour and growth of the infant. Similarly, it is uncertain how long these infants have been failing i.e. since early infancy or at one year? It may be, for example, that when an infant has had sustained failure to thrive for a long period of time, the mother becomes depressed due to an inability to resolve the growth problem herself. This could lead to other relationships in the family becoming stressful and increasing the likelihood of isolation from others. Furthermore, when cases do recover and show normal weight gain, does this mean that the quality of attachment between mother and infant has improved? There have been no studies that have examined the role of improving the attachment between mother and infant and measuring subsequent growth.

Other research has examined whether the mother is depriving her infant of adequate nurturing, due to unresolved problems of her own. For example mothers of infants who fail to thrive have been found to have social stress in their lives than control mothers (Ward et al, 1993). Furthermore mothers of failure to thrive infants have limited support from their family and have a poor relationship with their partners (Benoit et al, 1989). Some studies have found mothers to be aggressive, punitive and hostile (Hutcheson et al, 1992), while other studies have reported them as being indifferent towards their infant (Coollbear & Benoit, 1999). Other studies have included the role of the father drawing attention to the broken or distressed marital relationship and have noted the frequency of other stresses such as chronic or psychosomatic illness in other siblings. The research therefore indicates that other family relationships are a contributory factor. However, these observations are usually clinical impressions that have been formed without any valid assessments, or control groups.

Maternal depression has an increased frequency in mothers of infants with failure to thrive than controls, despite mothers of case and control infants experiencing a comparable number of life stresses (Wooster, 1999). Depression in the infant has also been discussed. In a review of infant depression (Guedeney, 1997) the problem was associated with maternal depression, attachment and relationship disorders, failure to thrive and protein energy malnutrition. The association between maternal depression and infant depression and the transmission of the disorder from mother to infant is difficult to explain. Depressed mothers appear to be more negative and less positive when interacting with their infants, similarly infants of depressed mothers are more negative and less positive when interacting with their mothers and possibly other adults (Siefer & Dickenstein, 1993). However, associations made between maternal and infant depressed are burdened by an absence of definitions and validated assessment scales

(Guedeney, 1997). These interactions may lead to an attachment problem. A number of studies have emphasised a relationship between failure to thrive and attachment disorders (Benoit et al, 1989; Ward et al, 1993). Using the strange situation procedure it was found that 90% of infants who were failing to thrive were insecurely attached to their mothers, compared to less than 50% for controls. Ward et al (1993) used an additional category of disorganised/disorientated to describe infants in the Strange Situation. The results showed that 35% of infants who were failing to thrive were secure whereas 46% showed disorganised or anxious attachments. This can be compared with controls of whom 64% were secure and 7% disorganised. The Adult Attachment Interview is an alternative means of investigating attachment between caregiver and infant. Benoit and Coolbear (1999) used this together with the Working Model of The Child Interview (WMCI), plus feeding and play observations to compare infants who were failing to thrive with controls. They found that the mothers of children who failed to thrive had greater incidence of attachment disturbance, non balanced WMCI classifications and less reciprocity during feeding. There were no group differences observed during play.

Studies of mother infant interactions during feeding have studied infants aged one year and over; these have usually been concerned with referred cases that require further investigation. In these studies mothers usually reported feeding problems occurring early in infancy. Mathisen et al (1989) studied mother infant interactions. The infants were aged one year and had no neurological damage. He reported that the feeding context for infants who fail to thrive were typically noisy, and the feeds took place in the living room rather than the dining room, the latter being more common for a control infant. The case infant was often badly positioned, either standing at a low table, or sitting in a baby walker, or lying on the mothers' lap. There was minimal verbal

interaction with the infant, and the infant consumed only semi solids or purees, which slid out of their mouths.

The aetiology of the relationship between attachment and feeding problems is unclear. It is useful to study other relationships besides mother and infant. Sameroff and Emde (1982) found the incidence of feeding disorders were greater in the families that had interfamilial relationship problems rather than a relationship problem between caregiver and infant. This view is a controversial one since it suggests that the infant has no control over its own pathology since its health is associated with the relationships between other family members. Studying other family relationships surrounding an infant with failure to thrive is gaining increasing recognition. Understanding generational as well as sibling relationships can help to develop intervention programs (Rodriguez et al, 1999). Inter familial relationships was studied in infants with failure to thrive by Crittenden (1987). It was found that maternal deprivation and family hostility, particularly family violence, was greater in the homes of infants who were failing to thrive than in maltreating homes or adequate homes. Crittenden argues that failure to thrive resulted from the insufficient and inappropriate treatment of the infant. The whole family appeared to be experiencing other psychosomatic manifestations of stress.

Mothers of infants who were failing to thrive describe them as being difficult to feed (Humphry & Rourke, 1991). Infants with failure to thrive are more likely to be highly distractible and have sensory problems (Wolfe & Glass, 1992). The infants are reported to react intensively to certain situations and are poor at adapting to new contexts, they also lack any daily rhythms (Fullard, McDevitt & Carey, 1984). The infants are less likely to use non verbal cues, their communication is lower than that of controls and

they often avoid social interaction with their mothers. There is evidence of reduced positive affect outside the feeding context, with fewer vocalisations and reduced motor activity (Berkowitz & Senter, 1987). The infants are unusually adverse to touch on their arms and face (Mathisen et al, 1989) and often try to resist touch, become distressed when approached, and have an indifference to separation (Powell, 1983). Once again the research suggests that there is some kind of attachment problem associated with infants who fail to thrive. It is unclear whether the infants' own behaviour initiates the poor interaction or helps maintain it. Some studies have taken a balanced view of both family and infant contributions to failure to thrive (Crittenden, 1987).

Hepstinall, Puckering, Skuse and Start (1987) conducted a study investigating mealtime behaviour of inner city children. The children were aged approximately four years. A group of children with failure to thrive were identified whose growth was below the 10th centile for their age. These cases were matched with control children on age, sex, socioeconomic status and ordinal position. The study provided insight into the feeding situation of the infants. Frequency of family meals was reduced in families of case infants, and often case infants ate independent of parental supervision. Mothers of case infants were more likely to become angry and use various techniques to persuade their infants to eat. The cases were also more likely to disobey their parents wishes. The feeding situation was also more likely to be noisy and chaotic in case homes. Infants with failure to thrive also showed evidence of poor oral co ordination. Infants with failure to thrive were introduced to solids at five and a half months of age compared to controls whom were introduced on average at four months. Independent feeding in infants with failure to thrive occurred on average at five months later than controls. The findings provide a valuable insight but there are some areas for improvement. It appears that socio-economic status was based upon co-habitee's last known occupation.

The subjects were matched on age, sex, socio economic status and ordinal position, but there was no mention of the subjects being matched on school/pre school or nursery factors. Similarly other familial characteristics such as maternal education/occupation and house ownership have not been detailed in the study. In the absence of these factors it is uncertain that all the relevant variables have been controlled for.

In addition to these measures some attention has to be given to the presence of other environmental stresses. Inter familial relationships, health of other family members and financial status needs to be examined. All of these factors can affect the moment to moment interactions between caregiver and infant, and similarly can affect the success of any intervention.

There has been research examining social factors in case and control families. Failure to thrive has been found to be related to the level of deprivation (Wright et al, 1994). The frequency of failure to thrive cases was lower in residential areas that were 'intermediate' and higher in residential areas that were deprived. The study also found that affluent areas showed slightly increased incidence of failure to thrive when compared to intermediate areas. The authors suggested that this was explained by breast feeding (Wright et al, 1994). Breast fed infants grow quicker than bottle fed infants during the early weeks of infancy but are more likely to be lighter than bottle fed infants at one year (Dewey et al, 1992).

In a study by Kotelchuck & Newberger (1983) a group of cases aged from 12-18 months were matched with controls for social economic status. The researchers found that families of infants with failure to thrive had little family or neighbourhood support regardless of affluence. Mothers of case infants compared to controls rarely saw other

members of their family. The mothers of case infants were slightly less well educated compared to controls, but there were no educational differences between fathers of case and control infants. The age of the case mothers was no different from that of mothers of controls and there was no evidence that mothers of cases experienced more social stressors that would prevent them giving their infant attention. A series of demographic measures were taken that included number of persons per household, number of months at present address, marital status. None of these measures were statistically significant between cases and controls. The conclusion of this research was that the theory that failure to thrive is a result of maternal behaviour needs to be re-examined. Furthermore, demographic factors do not differ from controls. This is important because the research suggests that failure to thrive is not primarily a deprivation effect.

1.2.7 Summary of factors that impair growth

This section has examined the various factors that impair infant growth. Oral motor dysfunction can prevent an infant from feeding efficiently, which can lead to frustration for both the infant and the caregiver. There are other feeding problems that have been identified in infants such as infantile anorexia and refusal to eat that lead to poor growth, but their origins are difficult to pinpoint and their relationship with failure to thrive is not clear. The home environment has been examined and certain contributory factors including deprivation and attachment have been isolated as the key to understanding feeding problems. How the home environment or maternal characteristics result in a feeding problem in the infant is hard to establish. Furthermore when an infant with failure to thrive recovers and gains weight normally, there is no

information on whether the relationship between mother and infant improved and initiated the growth or whether the attachment remained poor. If the infant is failing to thrive and the home environment does not appear to be at fault, the cause must be elsewhere. Feed type and nutrition will be considered in the following section.

1.3 Feed type and infant growth

If an infant's milk is of poor nutritional content, then the growth and health of the infant will be affected. An infant who fails to thrive may be receiving formula that has been over diluted, or they may not be offered enough milk to satisfy their growth needs. This section will examine the differences between breast and formula milk and how the contents of each might affect growth and development.

Breast milk provides a variety of immunological and psychological benefits as well as containing proteins, fats, lactose and lipids that provide energy for the infant (Saint et al, 1986). The composition of breast milk in an individual mother may differ from the left and right breast, with the left breast being slightly richer (Saint et al, 1986). In terms of infants who fail to thrive, it would require investigation to determine if the infant was consuming enough and whether the quality of the milk was sufficient. Formula milk models breast milk, but it does not contain the hormonal and immunological agents, enzymes and live cells that are present in human milk. The composition of formula milk has evolved over the years. Early infant formulas comprised cow's milk, sugar and water. The protein content of these milks was higher than that of human milk. The fat was highly saturated, contained few essential acids and was generally poorly absorbed by the infant. It would have been interesting to

discover the growth patterns of formula fed and breast fed infants during the early years of formula milk development. Infant formula milk now contains a number of dietary lipids and the fat content provides approximately 40-55% of the energy derived from formulas. Fat is important to growth. It has been estimated that during the first six months of life, fat accounts for 35% of infant weight gain (Fomon et al, 1982). Fat can also be obtained from carbohydrates and protein but a deposition of fat obtained from the diet is advantageous.

A great deal of controversy surrounds the issue of whether the type of feed an infant is exposed to can have long term affects on its growth and behaviour. Breast milk may be manipulated by introducing different foods to the mothers' diet, which subsequently flavours the breast milk (Mennella & Beauchamp, 1991a). Alcohol does not stimulate infant feeding behaviour less milk was consumed and the infants tended to sleep frequently for short periods when their mother had consumed alcohol (Mennella & Beauchamp, 1991b). It was evident that the alcohol interfered with the infants intake of milk. In the long term this could inhibit infant growth. There is some research that has shown consumption of alcohol in lactating mothers has a detrimental effect on infant motor ability at 1 year of age (Little et al, 1989). However, in one particular study of women in Mexico recommended to drink up to 2 litres of pulque (a low alcoholic drink) per day there was no difference in weight gain between these breast fed infants and control breast fed infants (Flores-Heurta et al, 1992).

Both vanilla and garlic (Mennella & Beauchamp, 1991) stimulate infant sucking on the breast. Similar findings have been observed in bottle fed infants whose formulas were flavoured with vanilla (Mennella & Beauchamp, 1993, 1996). This would suggest that the flavour of milk could influence the intake of the infants. The increase in sucking

may be explained by a phenomenon found in both children and adults: when the flavour and type of food is altered, intake increases (Birch & Deysher, 1986; Rolls et al, 1982). This phenomenon is also found in mammalian infants who suck more and demonstrate a variety of oral behaviours when feeding (Bridger, 1962; Korner et al, 1968; Terry & Johnson, 1987). Other studies have noted how exposure to flavours in milk via the mothers diet leads to a preference for those foods later in life (Campbell, 1976; Capretta et al, 1975; Galef & Henderson, 1972; Galef & Sherry 1973; Mainardi et al, 1989).

There is an absence of investigations of the long term affects of flavoured milk on adiposity in infancy. The Mennella & Beauchamp studies (1993, 1996) demonstrated that prolonged exposure of flavoured milk results in an elimination of the effect and the behaviour exhibited by infants is then similar to controls. The infants appeared to have accepted the odour and perhaps this acceptance may be explained by fatigued olfactory receptors (Rovee, 1972; Todrank et al, 1991). These are short term effects of flavoured milk but the long term effects have yet to be explored. Animal studies have revealed that an animal who receives flavoured milk accepts similar flavoured foods (Bilko et al, 1994; Galef & Sherry, 1973; Mainardi et al, 1989; Nolte & Provenza, 1991). Similarly, the more varied the animal mother's diet, the more likely it is that the offspring will accept novel foods during weaning and in later life (Capretta et al, 1975).

Each formula milk currently on the market differs slightly in their composition. Why they differ i.e. the potential gains of having more or less recommended dehydrated feed per 100 ml of reconstituted formula is unknown. If a mother chooses to reconstitute the formula but makes it more concentrated (i.e. add more powder than instructed by the manufacturer) she may do so in an attempt to increase her infants' weight. Alternatively

if a mother over dilutes the formula feed she may be increasing the risk of her infant suffering from failure to thrive.

A formula that is too weak will not contain the right mixture of nutrients, or a formula that is made too rich, may interfere with digestion and absorption and cause vomiting or diarrhoea. Ensuring that the feeds are correctly prepared is vitally important to the growth of the infant. Over dilution of formula milk or under dilution can lead to growth problems. Potur and Kalmaz (1996) investigated feeding errors made in the reconstitution of formula milk of infants aged from birth to four months. The research showed that mothers were inconsistent in the preparation of formula from one feed to the next with instances of under and over dilution of the feeds. The research showed that when compared to exclusively breast fed infants, the formula fed infants were significantly lighter in weight. The research did not find that the incorrect preparation of formula feed was due to mothers having low educational attainment, instead the authors suggested that the mothers did not read the manufacturers' instructions properly regarding feed preparation. Egemen et al (2002) found that 76% of mother in their sample incorrectly prepared the formula milk. Over dilution of formula can lead to protein energy malnutrition. If an infant is fed formula that is concentrated and is not offered water in between feeds, especially during the summer when more water is lost due to heat exposure, hypernatremic dehydration or obesity may develop. Egemen et al (2002) also found that the error in feed preparation was not due to low educational achievement in mothers as 69% were high school or university graduates.

There has been research into the benefits of reconstituting formula milk with bottled water as opposed to tap water (Rottoli et al, 1997). The research concluded that there were certain benefits of using bottled water as opposed to tap water. Tap water may

contain high levels of minerals and certain impurities that are not removed by boiling the water. Over time, the researchers suggest that this may interfere with the absorption and digestion of formula milk. This certainly has implications for growth. Tap water, particularly in Britain varies from one area to another. It may be useful for health professionals to advise mothers of infants with failure to thrive who are bottle fed, to ensure firstly, that they are firstly correctly preparing the feeds and secondly, to consider the benefits of using bottled water.

If the formula is correctly made and offered to the infant frequently and the infant is not consuming enough, then perhaps the problem is with the internal mechanisms controlling appetite. To establish whether formula was being offered frequently, a twenty four hour feeding diary could be obtained from the infant's mother, and this could be used to establish energy intake. The feeding diary should provide a record of the time at which the milk is offered, the volume consumed and any feeding problems such as vomiting etc. Infants normally gain weight at 1oz per day between the ages of 0 to six months and 0.5oz per day between six to twelve months (Fomon et al, 1974). If the problem does lie with the parents incorrectly preparing formula, then an educational program needs to be implemented.

The energy content of formula milk was manipulated by Fomon et al (1975) who determined how the composition would alter intake in normal infants. Fomon et al (1975) used infants eight to 111 days of age. The energy content of milk during this period is particularly important, especially if infants are consuming milk that is higher in energy than another infant. For ethical reasons, the manipulation of the content of formula milk could not be adjusted widely; however, Fomon administered formulas to two groups of infants that were either 54kcal per 100ml (formula 1) or 100kcal per

100ml (formula 2). Mean intake for infants in the formula 1 group was 735ml per day, compared to 540ml for infants fed formula 2. Although the formula 1 group consumed more milk, their mean energy intake was less (i.e. 389 kcal) than for infants fed formula 2 (i.e. 538 kcal). During the entire period of study (8-111 days) intake was on average 479 kcal per day for formula 1 infants and 561 kcal per day for formula 2 infants. The infants in the study were also exposed to additional foods other than formula milk. Infants fed on formula 1 consumed 'beikost' (complementary foods) that accounted for 2 % of their total energy intake during the period 8-41 days, and 12% for the period 42-111 days. For formula 2 infants, it accounted for 1% to 8% respectively. Weight gain also differed, formula 1 infants gained on average 29.8 g per day compared to 41.0 g per day for formula 2 infants. During the first test period of 8-41 days, formula 1 group consumed significantly less formula milk than formula 2 group.

In a subsequent study by Fomon et al (1976) the effects of fat and carbohydrate content on the growth of male infants was examined. Two groups of new born male infants were allocated to one of two conditions. They were fed either a formula that contained 29% of its energy from fat and 69% from carbohydrate (formula A); or a formula which contained 57% from fat and 34% from carbohydrate (formula B). The infants were studied for a total of 103 days. Generally, the results showed that infants fed formula A consumed more milk per day, the energy intake was greater and their gain in weight and length was more than for the infants fed formula B. However, despite this apparent difference, the findings could not be supported statistically. Therefore, the authors had to conclude that the weight and length gain for both groups was similar.

There are no studies available documenting what infants who fail to thrive are offered prior to diagnosis. Instead the inference has been made that since hospitalisation has

resulted in weight gain where sufficient food has been offered, the infant was fed inadequately at home. Hospitalisation has also removed the infant from the stresses of home life, so it is difficult to determine if failure to thrive is a result of inadequate intake, family stress or both. If environmental stress were producing a lack of appetite and lack of nourishment, then the infants' hormonal balance would be disrupted with changes in the growth hormone and cortisol levels. Crittenden (1987) proposes that in order to discover if infants with failure to thrive have these hormonal characteristics, a controlled study of physiological functioning and behavioural studies of the environment is needed.

1.3.1 Feed type and its affect on development

The choice of feed type has been associated with certain behaviours in the long term. These include sleep, growth and Bayley scale measures. The decision to breast feed or bottle feed can have other effects on the infants' behaviour.

In Wright's (1983) study, it was found that breast fed infants were more likely to first not wake during the night when they were 13 weeks of age, this may be compared to bottle fed infants who did not wake during the night by eleven weeks. Even at one year of age, a greater proportion of breast fed infants were still waking during the night. The study also showed that a greater proportion of infants who slept through the night were in social classes three, four and five. These classes also had a greater proportion of bottle fed infants. Further statistical analysis showed no effect of class upon waking; a significant effect of feeding method upon waking; and an effect of social class upon feeding method.

So why should the type of feeding influence night waking? One theory has been that human milk is digested quicker than bottle milk. However, new formula milk is more like human milk in its nutritional composition so this can no longer be a factor (Rowland et al, 1981). Another difference is the quantity of milk consumed throughout the day by breast fed infants compared to bottle fed infants (Wright, 1982). At two months, breast fed infants consume more in the morning and less at the end of the day. At four months, a switch occurs and large meals appear at the end of the day. Breast fed infants often wake out of hunger; however, continued waking at three years of age is not due to hunger. Similarly, night wakers did not eat larger breakfasts. Wright suggested the introduction of solids at an earlier age by bottle fed infants may be the reason. Finally, the mothers of bottle fed infants do not encounter as much physical strain as breast feeding mothers. This may in turn lead a lactating mother to become more passive and liberal, whereas a bottle feeding mother is more likely to be aware of the night waking problem and deal with it. The lactating mother may be unaware of a problem for quite some time.

The choice of feed type and its long term effects on growth has been studied in pre term infants. Lucas et al (1994) investigated breast feeding and developmental status at 18 months in 771 low birth weight infants. It was found that infants who had been breast fed had an 8 point mean advantage on the Bayley scale than formula fed infants. However, we must be cautious in drawing conclusions about this data. It is reasonable to assume that there may have been other factors affecting the outcome, for example, parental factors, before we conclude that breast milk affects the brain in a different way to formula milk. Despite making adjustments for social and demographic factors, breast fed infants still had a 4 point advantage in their test scores. The results may also

suggest that mothers who choose to breast feed their infants may reflect more concern for their infant's welfare and therefore the infant may receive more interaction and stimulation. Therefore breast feeding may be related to parental style. The long term affects of early feed type and childhood mental ability have yet to be collected.

Lucas et al (1989) compared a variety of early feed types. Infants were either exclusively breast fed (group 1); exclusively formula fed (group 2); partly formula fed with unfortified donor breast milk (group 3) or breast fed with supplements of donor breast milk. This procedure was adopted for the first 30 days, after which the mothers continued to either breast or bottle feed. The infants were followed up 9 months after the expected date of delivery and tested using the Bayley scale. Again differences were observed between feed type and scores on the Bayley scale.

The choice of feed type and its long term effects on growth has been studied in pre term infants. Lucas, Morely, Cole & Grove (1994) found that infants fed on donor breast milk and infants fed on pre term formula did not differ on Bayley scales at 18 months follow up. This is despite the low nutrient content of the donor milk in comparison to the fortified formula. In a previous study by the same authors, pre term infants fed standard formula milk did differ in their Bayley scores at 18 months, with the former group being the most disadvantaged. The breast fed infants did the best overall than the standard formulas milk. Explaining these results is difficult. The authors wish to support the argument that breast milk enhances neurological development.

Further benefits of choosing breast milk over formula milk have been demonstrated by Lucas & Cole (1990). Necrotising enterocolitis is a serious gastrointestinal disease that neonatal intensive care infants are prone to. The causes are debatable, but prematurity

and low birth weight are associated factors. Lucas et al found the incidence of this disease was six to ten times more common in formula fed infants than in breast fed alone and three times more common in those with mixed feeding.

1.3.2 Time of weaning and predispositions to feeding styles

An infant is introduced to solids around four months of age. This is an important dietary transition for them, and if they have had feeding problems earlier, this transition may be more difficult. Obesity is becoming an ever growing part of Western culture and appears to be resistant to treatment (Weil 1977; Myers & Young, 1979; Deitz, 1983). Infant nutrition is particularly important and certain protective measures, such as the delayed introduction of solids has been shown to prevent obesity in later life (Agras et al, 1987; Agras et al, 1990; Kramer, 1981; Kramer, 1985). Solid foods are recommended at 3-4 months of age, however, mothers who bottle feed their infants often introduce solids earlier than breast feeding mothers (Martin 1978). Previous studies have attempted to discover a relationship between the cessation of night feeds with factors other than the breast or bottle feeding.

However, there are so many factors that influence the development of obesity (e.g. genetics, different feeding practices of mothers, socio-economic group etc), that it is difficult to determine what combinations of factors are important in the single case. Kramer et al (1985) researched the factors that determine weight and adiposity during the first year of life. A number of variables were recorded. These included sociodemographic data, maternal attributes of early infant body image, maternal feeding attitudes questionnaire, socio-economic status, infant temperament questionnaire, infant

feeding practices, and weight and body composition assessments. Some patterns were identifiable in the data. For example, infants heavier at birth were more likely to be heavy or obese at six months and twelve months. Boys were more likely to be heavier than girls. Maternal and paternal body composition did not influence the infant's weight at six or twelve months, although it did affect birth weight. Maternal feeding attitudes were not found to be influential, a finding that is consistent with previous studies (Kramer et al, 1983). Maternal preference for a chubbier infant was partially fulfilled at twelve months. Although some mothers appeared more relaxed about the intake of their baby, it was found that these mothers later encouraged their infants to eat. The researchers concluded that although mothers experienced conflict between what they knew to be an appropriate answer on the questionnaire, it was a different to what they truly believed.

In a study by Agras et al (1987), it was found that vigorous feeding patterns (defined as high pressure sucking, long sucking bursts, with individual sucks being longer, shorter intervals between sucks, in combination with fewer but larger feeds) predicted the development of greater adiposity when the child was two years of age. In a follow up study of the same subjects at six years of age (Agras et al, 1990) similar feeding patterns predicted fatness at three years. The influence of feeding pattern decreased thereafter. Perhaps environmental effects or social learning become dominant at this point.

Animal studies have shown that a vigorous feeding style in pre obese mice did lead to obesity. Pre obese mice spent longer sucking which did not decrease as the mice matured. This is in contrast to lean mice, who gradually decrease in the amount of time sucking. The researchers suggested that the vigorous sucking pattern denotes a genetic

predisposition towards obesity in mice, but whether this is comparable with humans remains undetermined (Wilson et al, 1979).

Some studies have noted that vigorous eating of solid food in children and adults has been associated with fatness (Drabman et al, 1977; Drabman et al, 1979; Agras et al, 1987, 1990; Gaul, Craighead, Mahoney, 1975; Telch et al, 1988). There is experimental scope for study of the long term effects of rapid eating and adiposity.

1.3.3 Summary of feed type and infant growth

This section has examined a number of factors that may potentially affect growth. The problem may lie with the infant i.e. they may not suck well, preventing them from consuming an adequate amount. The infant may have an internal regulatory problem preventing them from experiencing hunger, or they may be hungry more frequently. The problem could lie within the feeding context or there could be a miss management of the feeding experience. In sum, feed type can be potentially affect long term growth and development. We must be cautious with evidence of this nature because the studies are often conducted on a small select sample, and this can potentially affect any results.

1.4 Studying infant feeding behaviour

Sucking may be studied in different ways. Each method tells the observer something slightly different. Each method and their observations are outlined below. A transducer system has been used in a number of studies to investigate bottle feeding (Demonterice

et al, 1992). This requires a small line attached to the teat that is usually filled with air. As the infant sucks, the pressure inside the line changes and an a/c converter records this output on a computer. By using this method developmental differences in the sucking pressure of infants can be investigated. However, there is an argument that the line leading from the teat should be filled with water and not air, since air filled lines do not respond rapidly to pressure fluctuations as do water filled ones. This may lead to false conclusions about the peak negative pressures. In sum, the transducer type rather than the age of the infant may explain the results (McGowan et al, 1991). Another problem is that water is often used to feed the infant rather than formula milks during investigation. Pacifiers have been used (Field et al, 1982, Bernbaum et al, 1983) which gives us information about how the infant sucks non nutritively, which may be different to nutritive sucking. McGowan et al (1991) used a Ross 45 ml volufeder and Enfamil nipple. A catheter was entered close to the base and exited near the hole for the milk. To account for vacuum effects within the nipple a second tube was inserted in the nipple that terminated in the bottle. This would give a more accurate reading of pressure. A transducer with a line filled with water, produced an output that was digitalised and stored on computer. The results obtained showed that as the infant developed their pressure did not alter developmentally but instead was variable. The inter suck intervals decreased with age but and volume per minute did not change statistically according to age. The study gives no mention of the duration of the feed. The duration of the feed is very important and since an older infant may spend longer feeding in order to consume enough energy to grow normally. Thus it may be that the duration of feed changes developmentally and therefore total energy intake is different according to the age of the infant.

Another way of measuring sucking is to use a Whitney strain gauge with a computer to record the electrical changes caused by movement. The Whitney strain gauge is approximately 1 mm in diameter and is placed under the infant's chin and secured with tape that reaches over the zygomatic bones. The raising and lowering of the infants' jaw provides a change in electrical resistance that can be detected by a plethysmograph. This provides an output which is amplified by an a/c amplifier which, in turn gives a cyclical tracing of the infants jaw movements.

A validity study (DeMonterice et al, 1992) was conducted on the Whitney strain gauge and an adapted nipple. The adapted nipple was linked to a transducer (Viggo-Spectramed Oxnard). The transducer measured the positive and negative pressures produced by the infant's tongue. Milk flowed through the transducer down the line and into the nipple of the bottle. The differences in pressure were therefore directly related to the infant's consumption of milk. The transducer was able to detect when milk was being taken (i.e. positive pressure when the infant sucked causing the transducer to rise, and negative when the infant paused causing the mandible to lower). The output from the transducer was again amplified and displayed on a polygraph. The results may be interpreted as the % of total agreement between the two instruments (Whitney gauge and the transducer). For the total number of sucking bursts there was a 99.3% agreement. The correlation coefficients for sucks within bursts was .97; duration of burst .99 and duration of pauses .99. The researchers concluded that the Whitney gauge is an accurate measure when the occurrence of sucking is of interest rather than the change in pressure.

There were instances when the adapted nipple displayed a trace yet the gauge did not. This occurred prior to a rest period or the end of the feeding episode. The researchers

account for this by suggesting that the infants sucking had become disorganised possibly with fatigue. These sucks were usually of very weak amplitude and gave a negative input, possibly denoting that the infants' tongue was resting on the nipple without actually sucking, hence no change on the Whitney gauge. Occasionally, both the Whitney gauge and the adapted nipple showed deflections from the baseline while the nipple was not in the infant's mouth. In other words, there was stimulus noise. What is interesting about this study is that the noise was so rare in occurrence. Before the onset of a feed, presumably when the Whitney gauge is in place, surely noise will be evident from the infant crying or moving with frustration in anticipation of the feed. Similarly, breaks during the feeding episode for winding would display noise. How does the equipment distinguish these feeding breaks from sucking? The researchers do not mention this, so the start and stop time of both instruments would suggest they commenced with the first suck and ended as soon as the infant was taken off the bottle. Details of this are not mentioned. Also, it would be interesting to know how noise differed in amplitude compared to sucking behaviour, i.e. whether they differ visually. It would be interesting to know how the researchers removed noise from both data outputs in order to compare them statistically.

The researchers used a sample of pre term infants of varying gestational age. They claim this adds further weight to the validity of their study i.e. the Whitney gauge can be used on smaller and larger pre term infants. The Whitney gauge is filled with mercury and can be used to study breast feeds, unlike the other transducers. Additional measures to observe disruption of breathing and swallowing would be needed to provide a more detailed account of the feeding episode. Each of these components have been observed in some sort of disorganisation in pre term infants (Mathew, 1991b).

Ardan et al (1958) used a cineradiographic film of breast fed and bottle fed babies. This technique involved coating the mothers nipple with a mixture of barium and lanolin. The bottle fed infants were given a 1:3 mixture of barium and milk in order to observe the passage of milk. It was found that breast fed babies took part of the areola into their mouth in addition to the nipple. From this method they concluded that the stripping action was more important than the sucking action, when obtaining milk. However, the research was not exploited to its fullest potential due to the risks associated with x-rays.

Ultrasound is a useful way of looking at the co ordination of sucking, swallowing and breathing. Bu'Lock et al, (1990) used it to examine these key factors in pre term and term infants. The infants were divided into three groups according to gestational age: 33-34 weeks, 35-36 weeks and 37-40 weeks. Tremors made by the tongue were more noticeable in groups 1 and 2 than in group 3. The infants in group 1 usually made four sucks to 1 swallow whereas term infants had a 1:1 ratio. The breathing also differed as pre term infants stopped to 'catch up' on breathing were as this behaviour was absent in term infants.

An effective means of studying sucking patterns is to video record the feed and analyse the sucking patterns afterwards using a computer program that converts the observations into a digital record. Babies feeding on bottles have two types of sucking: nutritive and non-nutritive (Mathew, 1991). Nutritive is characterised as a regular pattern of sucking usually one per second separated by pauses. Milk flows during nutritive sucking, however it does not flow in non nutritive sucking. Non nutritive sucking involves sucking twice per second separated by pauses. Sucking in breast fed babies is different to bottle fed babies since there is a grading response to the flow of the milk. Also

babies suck in bursts; a burst is a sequence of sucks with pauses of >2 seconds. The aim of Woolridge and Drewett's (1986) study was to investigate the sucking response in breast fed babies by comparing the effectiveness of two methods a) the video and computer program, with b) an intraoral pressure monitor. Woolridge & Drewett found a high correlation between sucking patterns recorded by direct observation and by intraoral pressure measurements. In other words, both methods were equally effective and showed the same findings. The presence of the probe did not interfere with sucking (Drewett & Woolridge 1972; Bowen-Jones et al, 1982). There are some problems with the pressure recording method. The line can become blocked by soft tissue either within the baby's mouth or from the breast, and small sucks may not be detected. This is why the method is rarely used. The direct method of observation does not interfere with the mother and baby and can be used in most circumstances.

Weber et al (1986) used an ultrasound scanner connected to a video recorder. Breathing was monitored using a Graseby Dynamics Apnoea Alarm. They demonstrated that sucking was followed by swallowing, and swallowing alone was not observed. Sucking involved a stripping action of the tongue without laryngeal movement. Both bottle and breast fed babies at four days of age swallowed after every suck at the start of the feed. Later during the feed this appeared to change, and a suck swallow ratio of two sucks per one swallow (2:1) or three sucks per swallow (3:1) were observed. Breast fed babies two to three days old swallowed after several sucks. Bottle fed babies swallowed with every suck at the beginning of the feed, this changed to two sucks per swallow (2:1) or more. All infants' breathing was interrupted during swallowing. In babies two to three days old, breathing was uncoordinated with the sucking rhythm. In babies four to five days old sucks occur at a certain point in the breathing cycle. Breathing increased as sucks increased and was interrupted by swallowing. Finally, some differences were

noted between breast fed and bottle fed babies. In breast fed babies the tongue rolled but in bottle fed babies it was piston like. When the tongue was at rest, breast fed babies rested with the nipple indented slightly. Bottle fed babies rested with the teat expanded. The changes noted in the suck-swallow ratio were more likely to be due to milk flow than maturation. During the first two or three days there is limited breast milk available; this changes around the fourth or fifth day.

1.4.1 Nipple units and milk flow

During bottle feeding, the choice of nipple unit affect the infants' sucking behaviour. If a nipple unit delivers too much milk, this will cause the infant to choke and spit the milk out. Therefore, the nipple units available on the market cater for different ages of infants, for example premature, or newborn. Other brands group their nipple units according to the number of holes present at the tip of the nipple i.e. one, two or three holes, describing them as slow, medium and fast flow. Studying the flow of the milk and the infants' ability to cope with it is may be important to the field of infant nutrition. Mathew & Bhatia (1989) used various pieces of equipment to study breathing (respirace bands) heart rate (electrocardiogram leads) and sucking pressure (transducer and catheter) in neonates. They discovered that milk composition or the flow rate of the milk can alter the breathing pattern during nipple feeding. Longer inhalations and exhalations were observed in infants fed formula milk than expressed human milk A higher frequency of sucking and breathing is observed in breast fed infants than formula fed infants.

The size of the feeding hole determines the rate of flow through the nipple. Mathew (1990) studied the contribution of hole size and nipple thickness in nipple units during bottle feeds. Hole size was recorded for a selection of popular branded nipple units. Air flow was measured by forcing air through the feeding hole and simulated sucks were used to measure milk flow. Variability of air and milk flow was observed across the selection of nipple units, both correlating significantly with the size of the hole. The nipple thickness accounted for only some of the observed variability. Some within brand variability in hole size was observed and the researchers suggested that the design of the nipple units should be adjusted to reduce this variability. In a subsequent study by Mathew (1991c) it was found that laser cutting the nipple hole rather than manually drilling it reduced the variability.

The infant needs to exert a certain amount of energy through sucking in order to consume milk. The milk flow determines how much energy is needed to do this. Mathew (1988) investigated the number of simulated sucks needed to deliver 120 ml of formula from various nipple units. The milk delivery between the brands. High flow nipple units (SMA Nuk-type) required fewer sucks than slow flow units (Ross Twist-on standard).

The only disappointing feature of Mathew (1988) and Mathew and Bhatia (1989) research was that simulated sucks were used rather than observing infants directly. It would have been interesting to know how infants differ when their nipple units are changed. The implications of this research are important. It would enable better design of nipple units and help establish how pre term and term nipple units should differ. It could be beneficial to give infants who suck poorly high flow nipple units whereas hungry infants could have their intake reduced with slow flow units. If an infants intake

can be influenced by the size of the nipple unit, it may be useful to give high flow units to infants with failure to thrive in order to increase their intake. However, whether the infant could cope with a high flow unit without choking or spitting would be of concern. If the infant could not cope with the high flow, it would indicate that not only do infants with failure to thrive have inadequate intake but they have problems regulating their sucking, swallowing and breathing during the feeding episode. Research examining the feeding behaviour of infants with failure to thrive with different units would be beneficial to the study of infant nutrition.

1.4.2 Clinical application of studying sucking behaviour

There are clinical applications of studying sucking in infants. An interesting piece of research using pacifiers studied the effect of non nutritive sucking during tube feeding on pre term infants (Field et al, 1982). The researchers compared an experimental group provided with pacifiers during tube feeds with a control group who were not given pacifiers during feeds. Pacifiers were available to both groups at all other times. Infants provided with pacifiers required on average fewer tube feeds and fed from a bottle three days earlier than controls. Weight gain per day was greater in the pacifier group, who were subsequently discharged from hospital eight days earlier than the control group. This early discharge could prove to be very cost effective for the hospital. However, when behavioural measures were taken for both groups using the Brazelton Neonatal Assessment Scale, the pacifier group were slightly more impaired in their responses. The researchers offer no possible explanations. The restful nature of non nutritive sucking may have given rise to more relaxed responses to stimulation. The control group were tested closer to gestational age, because they were hospitalised

for longer. Finally, as sucking requires so much energy expenditure the case infants may have been tired.

1.5 Summary and aims

The identification of non organic failure to thrive and its treatment is an important area of infant health. Failure to thrive frequently has a very early onset. In a study by Drewett et al (1999) in a cohort of infants in the Newcastle upon Tyne area, those infants who failed to thrive within the first 18 months generally showed poor weight gain since birth. These results are consistent with finding from other research. In a prospective study conducted in the USA, 60% of cases failed to thrive by the age of one month and this figure increased to 87% by the age of 3 months (Altemeier et al, 1985).

These leads to the possibility that infants who are identified early in infancy with failure to thrive i.e. within the first three months, may have feeding behaviours that differ from controls. Studying feeding behaviour within this period provides a number of research opportunities. Firstly, if the study of feeding behaviour was restricted to the pre weaning period, this would enable the study of sucking behaviour in early infancy using procedures already described (Woolridge & Drewett, 1986). It would tell us a great deal about early feeding behaviour in infants who fail to thrive and controls. Secondly, studying pre weaned infants would avoid the problems involved with studying older infants i.e. those aged one year and older, whose feeding behaviour may be explained by a number of other factors such as timing of the introduction of solids which may account for their poor growth.

The identification of infants who fail to thrive in early life cannot be detected using traditional criteria, for example using a particular centile as a threshold. This is because during early infancy weight gain is influenced by birth weight. Therefore, infants with a high birth weight typically show slow weight gain whereas infants that are lighter at birth may gain weight rapidly. This point was discussed earlier in relation to regression to the mean (Cole, 1995). Also selecting infants cannot be done solely on clinical referral, since this would not provide a representative sample of all instances of failure to thrive.

An appropriate method of identifying failure to thrive in early infancy is using Thrive Index (Wright et al, 1994). Since early detection of failure to thrive in early infancy is a novel procedure it would be important to follow up infants at one year to monitor their growth.

The aims of this study were fourfold.

The first aim was to identify failure to thrive cases in early infancy using the Thrive Index (Wright et al, 1994a) in a community based study. The infants were identified from the Millennium Baby Study, a collaborative research program between the Psychology Department at Durham University, and The Department of Child Health, Newcastle University. The Millennium Baby Study recruited 1000 infants born in either the Queen Elizabeth or Royal Victoria Infirmary, between June 1999 and June 2000. The Thrive Index was used to identify changes in the growth velocity of the 1000 infants, based upon their birth weight and their 6 week health check. Controls were selected randomly from the Millennium Baby Study cohort. The growth of the infants was monitored for one year.

The second aim of the study was to examine the family characteristics of the cases and controls. We wanted to know more about the cases and controls other than their feeding and growth. A second questionnaire contained information on the familial characteristics of cases and controls. This was important since it allowed us to explore further the deprivation issue associated with failure to thrive.

The third aim was to compare the feeding behaviour of the cases and controls. A number of different measures were used to assess various factors regarding infant feeding. The observational method (as described in Woolridge & Drewett, 1986) was used to observe two consecutive milk feeds in cases and controls aged between 8 and 12 weeks. Differences between cases and controls in their sucking behaviour was investigated.

Another issue related to feeding was the accuracy of mothers reconstituting formula milk. Therefore samples of the formula milk were taken prior to each feed observed and chemically analysed. Additional data was provided by mothers' on a questionnaire. The feeding questionnaire was distributed to all mothers when their infants were six weeks of age. This recorded details of mothers' perceptions about their infants' feeding behaviour (see appendix 5). Obtaining information of this nature from mothers is useful since it can help identify other issues that need further investigation. A feeding diary (see appendix 10) was given to mothers two days prior to the observation of feeds.

The fourth aim was to monitor the growth of the cases and controls over the first year.

Chapter 2:

Methods

Chapter Two

Methods

2.1 The Millennium Baby Study

The Millennium Baby Study was a research program designed to investigate infant growth in a Gateshead cohort of 1000 infants. The study was based in the Department of Child Health at Newcastle University. The Millennium Baby Study comprised two separate studies that examined growth and nutrition in infants. These two studies were the Feeding and Growth Study and the Iron Deficiency Study. This thesis was carried out in collaboration with the Feeding and Growth Study. The aim of the Feeding and Growth Study was to investigate why some infants fail to gain weight fast enough after birth. The majority of infants gain weight easily and grow normally, however in some infants growth is poor and they are described as failing to thrive. Poor growth may be a result of an appetite problem or abnormal feeding patterns; however, there is little known about early feeding behaviour and weight gain in children who fail to thrive. The Feeding and Growth Study was designed to collect a substantial amount of information about early infant feeding behaviour. Mothers and their infants were invited to participate in the Millennium Baby Study soon after birth. The growth of the infants was monitored and cases of failure to thrive were identified at six weeks using a Thrive Index (Wright et al, 1994). The growth of the infants was monitored at four months and twelve months to identify cases that were still failing to thrive. The study enabled a large amount of information to be collected about the nature of feeding behaviour of infants identified with very early onset of failure to thrive and that of sustained failure to thrive at four and twelve months.

2.1.1 Recruitment

Ethical approval was obtained from the Local Research Ethics Committee, and the study had the full support of senior health professionals in the Health Care Trust. The specific aim of the study was to determine why some infants fail to gain weight fast enough after birth. The recruitment phase commenced in June 1999 and ended in June 2000. This project required collaboration from a number of health professionals, and written information was provided for them at the onset of the study (e.g. appendix 1). For example, community midwives were asked to trace mothers who had been discharged from hospital before the recruitment could take place. Community midwives, health visitors and ward midwives were each asked to rate the infants' feeding behaviour once. Health visitors were asked to provide the Department of Child Health with mothers' Edinburgh Postnatal Depression Scale scores at the three month home visit.

All expectant mothers received an information sheet (see appendix 2) at their 28 week antenatal check. This sheet provided them with information about the study and details of the recruitment weeks. The sheet had a form attached that mothers could complete, which would allow them to be phoned by a research assistant soon after their infant had been born. This was to ensure that if the infant was born during a recruitment week but was not approached by a research assistant, the mother would be phoned and an appointment for a home visit would be arranged.

The 1000 mothers and their infants were recruited while recovering from labour in the Queen Elizabeth Hospital, Gateshead or the Royal Victoria Infirmary, Newcastle. A timetable specifying the recruitment weeks had already been planned prior to the start of

the study. Only infants born during the recruitment weeks were recalled. A recruitment week commenced after midnight on Friday one week and ended at midnight the following Friday. The 1000 mothers and infants were recruited between June 1999 and June 2000 and they were all approached by a Millennium Baby Study research assistant, soon after giving birth. Upon arrival at the hospital, the research assistant found out from the ward staff how many births there were since the previous visit. The research assistant spoke to each mother in person, and it was estimated that approximately two thirds of all mothers were recruited in the hospital, the remaining third were recruited at arranged home visits by the research assistant. In cases where the infant was admitted to the Special Care Unit, the research assistant discussed the infants' progress at each visit and only mothers of recuperating infants were approached. As soon as a mother was recruited to the study, a letter was sent out to the community midwife, the health visitor and the GP.

Each mother recruited to the study signed a consent form (see appendix 3) and was provided an information pack that contained information about the Millennium Baby Study and a Personal Child Health Record (PCHR). This was a small booklet that contained information about caring for infants, and had forms provided that could be filled in by health professionals regarding weight and illnesses etc. These forms had duplicated copies that, once completed, could be removed by the health professional and forwarded to the Millennium Baby Study administration office situated in Gateshead. These weights, together with information mothers provided on the questionnaires given at 6 weeks, allowed careful monitoring of each infant's growth.

Mothers recruited to the study were asked to provide information about their infants at various key stages. One source of information was the questionnaires. One of these was

completed during recovery in the labour ward with the Millennium Baby Study administrator present (see appendix 4). The second was posted to mothers when their infant was 6 weeks of age (see appendix 5). The six week questionnaire asked mothers to write down the serialised weights from various health checks since the birth of their infant. These weights were entered into the Personal Child Health Record (PCHR) booklet by a health professional after each health check. There were duplicate pages for all weights entered into the PCHR. Once the table within the booklet was completed, the health professional was asked to post these pages to the Millennium Baby Study administration office.

2.2 Identifying early onset of failure to thrive

The aim of this study was to identify early onset of failure to thrive and study the feeding behaviour of affected infants compared to controls. Identifying and monitoring the infants was done at key stages during the first year. The routine health checks at six weeks, four months and twelve months provided the opportunity to obtain weights for the infants.

The previous chapter discussed in detail various techniques used for identifying poor growth. These techniques included using a threshold, whereby once a certain centile on the growth chart has been crossed, the infant is identified as failing to thrive. A number of different centile positions have been used as the threshold for identifying failure to thrive, for example, the 3rd (Wilcox et al, 1989); the 5th (Drotar et al, 1995) and the 10th (Dowdney et al, 1987). The problem with threshold based approaches is that a large number of infants with low birth weights would be identified, and larger born infants whose weight gain was nonetheless poor would not necessarily be detected using this

criteria. An alternative approach is to use a change in centile position, for example, infants who cross two or more centile positions are identified as having poor growth (Edwards et al, 1990). The problem with this technique is that it is not always applicable to different populations (Wright, 1995). For example, large infants who fall towards the mean would be identified as having poor growth even though they are within the norm (Corbett, Drewett & Wright, 1996). The method chosen to identify failure to thrive here, was the Thrive Index (Wright et al, 1994). This is a measure of growth velocity that can be used to identify infants for further investigation.

2.2.1 Identifying case and control infants

Early failure to thrive was identified by using the birth weight (Time 1) and weight at six weeks (Time 2). A Thrive Index (Wright et al, 1994b) was used as an indication of whether each infant was gaining weight appropriately or not. Since all of the Millennium Baby Study data was collected until the end of the study, a previous data set (Gateshead Data Set or GDS) was used to obtain the regression formulae and for identifying the slowest growing 10% of infants. The GDS was collected by Dr. Charlotte Wright, and contained the weights of a large sample of infants in the Gateshead area. The final figures in the formulae, and for the threshold detailed below, were calculated when all of the data was finally collected for the Millennium Baby Study cohort.

The birth weight (Time 1) was taken from the recruitment questionnaire and the six week weight (Time 2) was taken from the returned six week questionnaire. The two weights that were used for the calculating the Thrive Index can only be assumed to have been collected according to a standard medical protocol. By this, it is required that

weights are collected using a specified procedure. Birth weight must be collected as soon as the infant is born, naked using calibrated scales and accurately recorded by the midwife. Six week weight needs to be collected ensuring that the infant is naked using calibrated scales and is recorded correctly in the PCHR book. If either or both of these weights are not collected according to this procedure there is a risk that the weight that is recorded is inaccurate. If inaccurate weights are then used to calculate how that infant is growing, there is a chance that the growth of the infant that is calculated is also inaccurate. With regard to the Millennium Baby Study this could mean that there was a chance of error when calculating the Thrive Index. It can only be assumed that because the midwives and health visitors were informed of the nature of this research that extra care would have been taken when recording these weights. However, it must be recognised that there was the opportunity for error to occur.

The number of returned six week questionnaires therefore determined the size of the study sample. The number of returned six week questionnaires was 75% or 750 of the 1000 recruited. To predict each infant's six week weight, based upon the average of the study population (n=750), the following regression formula was used (Wright et al, 1994b).

For females:

Average z score at six weeks = $0.152 + 0.676$ (birth weight z score)

For males:

Average z score at six weeks = $0.046 + 0.714$ (birth weight z score)

The next step was to calculate a Thrive Index for each infant. The Thrive Index is the difference between the infant's actual z score at six weeks and their expected z score weight at six weeks:

$$\text{Thrive Index} = \text{Average z score six weeks} - \text{actual z score six weeks}$$

If the calculated value of the thrive index is 0, the infant has average weight gain. If the value is positive, the infant has above average weight gain. If the value is negative, the infant has below average weight gain.

The next task is to identify the slowest growing 10%. The slowest growing 10% provided the Feeding and Growth Study with a selection of potential cases for analysis. To identify the slowest growing 10%, a threshold was set for each sex.

If the Thrive Index was less than -0.803 for females, the infants were identified as cases (slowest growing 10%). If the Thrive Index was less than -0.871 for males, the infants were identified as cases. The number of female cases were 38 and the number of male cases were 37. These provided in total ($n=75$) the slowest growing 10% of the available study population ($n=750$).

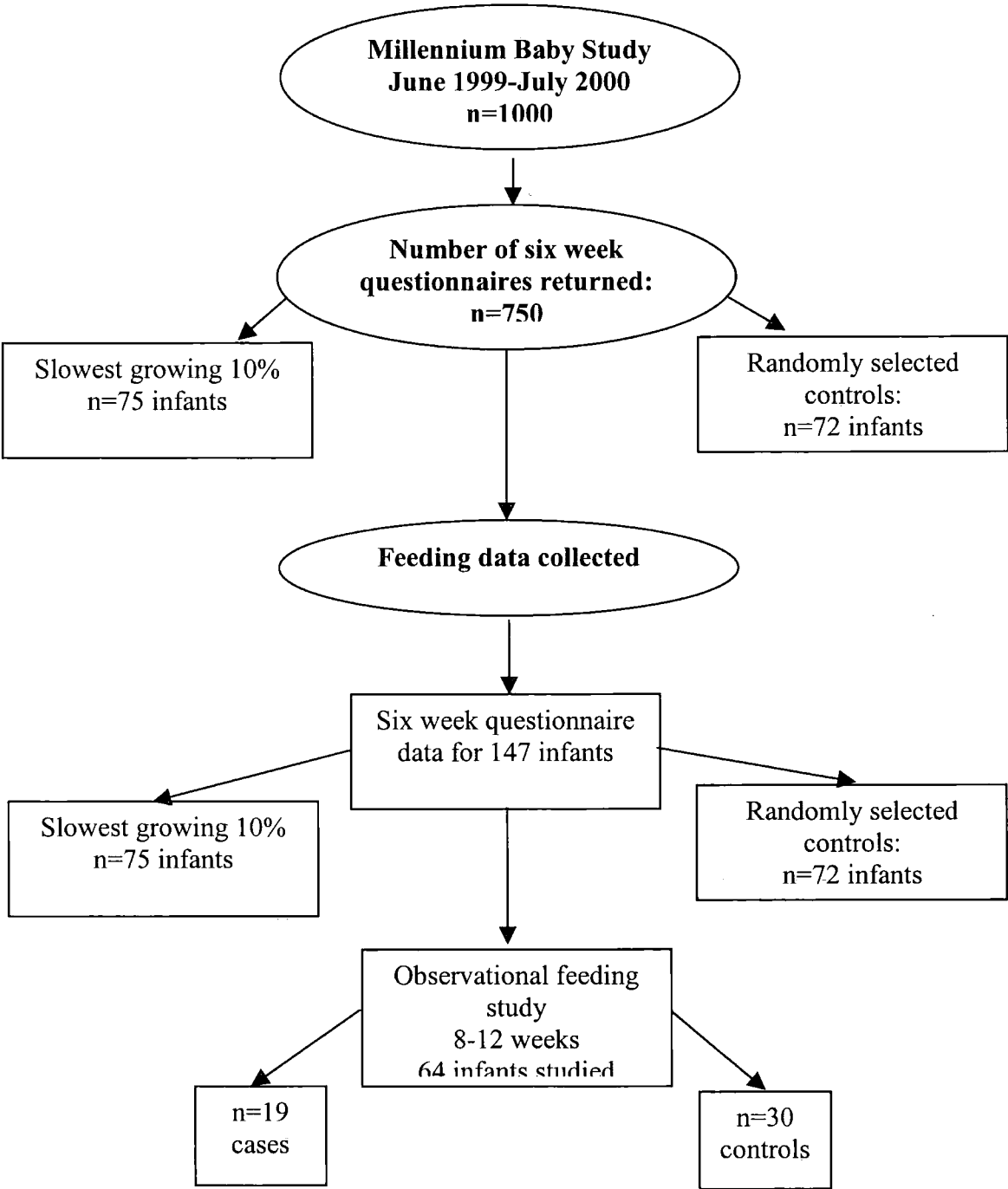
The next task was to select control infants. These were identified by selecting one potential control at random in each cohort of ten infants. For example from identity numbers 20 to 30, the randomly selected number was 23. If the control proved to be a case, the next identity number of the returned questionnaire was used as a control instead. For example, let us assume that number '23' was randomly selected as a potential control in the cohort of numbers '20 to 30'. The six week questionnaire was

returned but, the subject was identified as a case; therefore, subject '24' was selected as a potential control. If subject '24' did not return their six week questionnaire, then subject '25' would be selected as a potential control for the cohort of subject numbers '20 to 30'. Once this procedure had been implemented, there were 72 controls available for study. Of these 72 controls, there were 42 females and 30 males.

This provided a sample of 147 infants for the reported study in this thesis. The study compared cases ($n=75$) and controls ($n=72$) on a number of different measures. These measures included familial characteristics, growth velocity to four and twelve months and feeding behaviour. The feeding behaviour data were collected on the six week questionnaire, by direct observation between the ages of eight and twelve weeks. Figure 2.1 summarises this information.

Figure 2.1 Subjects studied

Flow diagram shows the number of infants initially recruited at birth, returning six week questionnaire and taking part in the study



2.2.2 Attrition

A total of 147 subjects were selected to be studied. For the observational feeding study, a total of 49 infants were studied. Of these 49 subjects, 19 were cases and 30 were controls (n=49).

The short fall in numbers from 147 to 49 can be explained by a number of reasons. The experimenter made contact with these mothers by telephone, following a letter posted to them explaining the feeding study. Contacting the mothers by telephone was often problematic. Some of these mothers did not own a telephone, or the telephone number was incorrect, or they had been disconnected. If the mothers could not be contacted by telephone, the experimenter visited the address on the chance that they were home. If there was nobody at home, the experimenter left a note from the Department of Child Health, with a contact address and telephone number. If the mother did not respond to the note, after 24 hours, a second visit was paid to the address, and a note was left again. This procedure continued until the mother responded, or the infant became too old to study, i.e. 12 weeks was the cut off point.

However, there were other reasons that explained the repeated lack of response by mothers. Sometimes the mothers returned their six week feeding questionnaires when their infants were already too old to participate in the research. Another reason that prevented mothers taking part was the amount of information the Millennium Baby Study required. Some mothers complained that the amount of information required was unreasonable. For all of these reasons, it was difficult to recruit mothers to the observational feeding study. Table 2.2.2a shows a summary of the main reasons for refusing to participate and an analysis according to cases and controls. It can be seen

that there was no difference between the two groups according to willingness to participate. It was perhaps the perceived intrusive nature of the study, i.e. the video recording of feeds and measuring mass consumed, that prevented many mothers from taking part. In any home based research we must respect an individual’s right to privacy and the opportunity to refuse participation.

Table 2.2.2a Analysis of cases and controls according to willingness to participate

	Cases	Controls
Participated	19 (25.3%)	30 (41.7%)
Refused to participate	39 (52%)	25 (34.7%)
Infants too old to participate	8 (10.7%)	10 (13.9%)
Could not be traced	9 (12%)	7 (9.7%)
Total	75 (100%)	72 (100%)

Chi-square = 5.945, df = 3, p =.11

2.3 Methods for studying infant feeding behaviour

The aim of the observational feeding study was to compare the feeding behaviour of case and control infants. This section outlines the procedure for studying infant feeding behaviour. All mothers of the cases and controls were asked to participate in the feeding study. The feeding study involved taking a video recording of two consecutive milk feeds in each infant. The video tapes were then coded so as to transcribe the sucking behaviour of the infant at each feed. From these recordings the sucking

behaviour of cases and controls was compared. Additional information collected at time of follow up was weight and length, mass of milk consumed and duration of feed and, if bottle fed, a sample of formula milk was collected. A sample was taken to investigate its dilution.

2.3.1 Apparatus and questionnaires

Sartorius scales (model 3865MP) were used to weigh all infants during the first four weeks of the study. These scales were accurate to 0.1 g up to 16 kg. However, these scales were exceptionally heavy and very difficult to transport, Seca scales (model 835) were therefore used temporarily to weigh infants. These scales were accurate to 20 g up to 14 kg. Finally, Seca scales (model 727) were obtained and used to weigh all subsequent infants. These scales are accurate to 2 g for an infant that weighed up to 10 kg and 5g for an infant over 10 kg.

A smaller set of scales, Ohaus CT1200-S was used to weigh the infants' feeding bottle before and after each feed to establish the quantity of milk consumed.- These scales were accurate to 1g up to 1500 g. Formula samples were taken using 10ml Plastipak sterile syringes, and were placed in 7ml Sterilin sterile bottles, frozen on the day of collection and stored at -20 C. These were used to determine the dilution of the milk. The sample was taken prior to the feed and prior to the weighing of the feeding bottle.

Infant length was measured using Kiddiometre equipment (supplied by Raven Equipment). The measurement range of this equipment was 0-100 cm. The experimenter received a day of training at the out patient children's ward at the Queen

Elizabeth Hospital, Gateshead. The day of training involved observing the correct technique from a qualified nurse and then practising on infants under the guidance of the nurse.

A Sanyo camcorder (model EX-20P) and tripod were used to video record the sucking behaviour of each infant whilst feeding.

Additional information regarding infant feeding was obtained by analysis of two questionnaires, one provided at the time of recruitment i.e. soon after the infant was born (appendix 4); the other when the infant was 6 weeks (appendix 5). The questionnaires were designed by Dr. Katherine Parkinson from the Department of Child Health, Newcastle University. The questionnaire provided on the day of recruitment contained four sections, and was completed by the person doing the recruitment who asked the mother the questions. These sections within the questionnaire are outlined below. Additional questionnaires were posted to mothers when their infant was four, eight and twelve months of age. The questionnaires had space provided for mothers to give the latest series of weights for their infant, obtained from clinic visits. Therefore, in terms of growth, the research would have a birth weight, 6 week weight, weight at follow up where applicable (8-12 weeks), a four month and twelve month weight. If a twelve month weight was not available, the eight month weight was used instead.

Recruitment questionnaire (Appendix 4)

Section A:

Milk feeding

This section asked mothers to give details about how they intended to feed their infant i.e. breast or by bottle.

Section B:

General feeding questions

This section asked mothers to rate their infants' early feeding behaviour e.g. their sucking, appetite, and other meal time behaviours such as crying, sleeping etc.

Section C:

Looking into the future

This section asked mothers to provide information about how they expected to feed their infant in the future. For example: would the infant be woken to feed if their sleep interferes with regular feeding times?

Section D:

General information

This section asked mothers to provide information about their social and economic status. Questions included concerned their education level, home ownership and marital status.

In sum, this questionnaire gave details about the infants' early feeding behaviour, and about the mothers' judgement about their infants' behaviour during mealtimes. Section D provided important details about their current social situation of the case and control infants. The analysis of this section is presented in Chapter 3. Comparing case and control families would determine if there were any differences between the groups.

The second questionnaire was posted to mothers when their infant was six weeks of age. Once completed this questionnaire provided details about the health and current feeding behaviour of the infant. The questionnaire also asked mothers to provide serial weights for their infant since birth. The mother had access to this information from the Personal Child Health Record (PCHR). This booklet is issued to each mother on the day of recruiting, and contained a section where serialised weights, including birth weight were recorded. This page also had duplicated copies that were removed and posted to the Millennium Baby Study administration, by health professionals after routine health checks. These weights were checked against health records for accuracy and then used as a basis for selecting cases and controls using the Thrive Index. The questionnaire contained five sections and each of these is outlined below.

Six week questionnaire (Appendix 5)

Section A:

Milk feeding

This section asked mothers to give details about the choice of feed for their infant i.e. breast or bottle or both. The mother was also asked how many feeds the infant had

per day, how much was consumed and the duration of the feed. There was a section for mothers who initially breast fed their infant and had changed to bottle feeding. The questions were designed to establish why this change had occurred.

Section B:

Weaning

Although it is recommended by health professionals that infants should not be weaned until four months, there was a possibility that some would be weaned before this age. This section was to identify the infants who were receiving additional feeds and to establish why the infants had been weaned earlier than recommended. If the infant had not been weaned, the mother was to miss this section and move on to the next one.

Section C:

General feeding questions

This section was similar to Section B on the recruitment questionnaire. Mothers were again asked to rate their infant's sucking and appetite, and describe additional behaviours that may occur during mealtimes e.g. crying, vomiting, sleeping. Also the mother was asked their infants' appearance i.e. whether they were fat, thin, average.

Section D:

Baby's illnesses

This section asked mothers to provide details of any illnesses their infant had since birth, and whether a doctor had been consulted.

Section E:

Baby's behaviour

This section was subdivided into four categories: feeding, sleeping, bathing and dressing and daily activities. This gave an indication as to the mothers' opinion of her infants' behaviour during these activities. Each section provided an opportunity for mothers to rate on a scale of one to seven, how frequently the infant behaved in a certain way.

The data within sections A and C are analysed in Chapter 5. They were designed to obtain mothers' perspective of the milk feeding behaviour of her infant. The mother's perspective on milk feeding was important to consider, since previous research has shown that mothers of children who fail to thrive describe them as difficult feeders for one reason or another. The previous chapter discussed in detail various studies that described the behaviours during feeding exhibited by children who fail to thrive (Wolf & Glass, 1992) and those who refuse to eat (Chatoor et al, 1997; Dahl, 1987; Dahl, 1992). Comparing the responses of mothers of case and control infants to questions on this issue was another important part of this thesis. The mother's perspective on milk feeding her infant provided a comparison with the observed behaviour of the infants

during the observational study. At the follow up, two consecutive milk feeds were video recorded.

In summary, the details of this questionnaire were important for two reasons. Firstly, the infants were identified as cases and controls at the age of six weeks, so the mother's perspective on feeding an infant with early onset of failure to thrive was important. Secondly, the details of the questionnaire were provided a short time before the follow up study. Therefore comparing the details of sections A and C are important to compare to the follow up data, to compare what mothers reported about their infants behaviour and what the observational feeding study revealed.

Four month, eight and twelve month questionnaires

A four month questionnaire was subsequently posted to mothers when their infants were four months of age, and an eight and twelve month questionnaire when the infants were eight and twelve months of age. Each questionnaire coincided with a routine health check i.e. vaccination and weight measure. Each questionnaire contained a section for mothers to transcribe their infants serialised weights since the previous health check. These weights were taken from these questionnaires. The data points of interest were the four month weight and twelve month weight. The twelve month weight provided the final data point for the growth analysis for the study cohort. If the twelve month weight was not available the eight month weight was used. The remaining sections on both questionnaires were not used for analysis in this thesis, since the aim of this thesis was restricted to the study of early infant feeding behaviour in case and control infants.

2.4 Procedure

The community health visitors were aware of the Millennium Baby Study, but an additional information sheet was given to them informing them of the additional study involving the direct observation of sucking patterns of young infants (see appendix 3).

Mothers who agreed to participate in the Millennium Baby Study were asked to return a questionnaire when their infant was six weeks of age (see appendix 5). The completed questionnaire contained the infant's current weight, and this, together with the birth weight and the thrive index, was used to identify the cases and controls. The procedure for this has already been outlined in detail in section 2.3.1. Once the cases and controls were identified, a letter from Dr Kathryn Parkinson was sent to the mothers informing them of a study of infant sucking behaviour (see appendix 6). The experimenter remained blind as to which were controls or cases while the observational feeding data was being collected. Once all data collection was complete, the experimenter was given a list of all infants and their status (i.e. cases or controls).

It was anticipated that mothers would be more willing to participate if they were studied in their own home as opposed to travelling to a laboratory. Given that the majority of the research was done in deprived areas, mothers may not have the resources to transport themselves and their infant to a laboratory, which would affect the number of infants that would be studied.

The name, identity code, address and telephone number of cases and controls were passed on to the experimenter weekly. The number of mothers' whose details were passed on depended on the number of six week questionnaires returned, and whether the

subject details and selection procedure identified them as a 'case' or 'control'. The selection procedure was controlled by Dr. Charlotte Wright, a paediatrician working at the Department of Child Health, Newcastle. The experimenter contacted the mothers initially by telephone and arranged to meet each mother individually to discuss the study. If the mother did not have a telephone, or was ex directory, a visit was made to the house to see the mother and discuss the study. This visit usually took place three days prior to the anticipated day of study. During this initial visit, the experimental procedure was explained fully, an information sheet was provided (see appendix 7) and any questions answered. The mother signed a consent form (see appendix 8) that was identical to the consent form they signed while they were still in hospital. This was to ensure consistency, and also the mothers would be reassured to see familiarity in the procedures. Another appointment was made to observe the infant during two consecutive feeds. The mother was given a milk diary (see appendix 9) in which she logged a) the time at which each feed commenced and duration of feed, b) if bottle fed, the amount consumed c) any problems related to feeding. The mother was asked to record this information for 48 hours prior to the experimenter's return.

On the day of the study the experimenter arrived at the mother's home half an hour before the expected first feed. The experimenter was equipped with two separate data sheets, one designed for breast feeds (appendix 10) and one designed for bottle feeds (appendix 11). The experimenter would ask how the mother intended to feed her infant, i.e. breast or bottle, and then select the appropriate data sheet. Both data sheets were designed to record the sex, name and date of birth of the infant. After this information was collected, the appropriate procedure according to feed type was followed. The procedure for breast and bottle fed infants is outlined below.

Breast fed infants

The breast fed infant's naked weight was recorded in kg and the infant's length was measured in cm using a Kiddiometre. The naked test weight was used to monitor the growth of the case and control infants during the first year of life. The infant was dressed again and weighed. Time of feed was recorded. A Sanyo camcorder focussed on the infant's mouth visually recorded the sucking behaviour. Once the feed was over, the camera was turned off and the dressed infant weighed again. The difference between the weights was used to measure the milk consumed by the infant.

The experimenter arranged to return to the home later in the day to observe the next feed. The procedure was repeated for the second feed, but the naked weight and length measurement were omitted. Finally, the feeding diary was collected. Table 2.4a shows a summary of the data recorded for each feed.

Table 2.4 a**Summary of data collected for breast fed infants**

<i>Feed</i>	<i>Data collected</i>
First	Naked weight (prior to feed) Length (prior to feed) Dressed weight (prior to feed) Dressed weight (after feed)
Second	Dressed weight (prior to feed) Dressed weight (after feed) Feeding diary collected

Bottle fed infants

The infant was weighed (kg) without clothes or nappy and length was measured in cm using Kiddiometre. The infant was dressed again and weighed (kg). The two weights of the infant i.e. dressed and undressed was to standardise the procedures for both breast and bottle fed infants. The naked test weight of the infant was used in the growth data analyses of the serial weights. A small sample of the formula milk was extracted from the infant's feeding bottle prior to each feed using a sterile Plastipak 10 ml syringe. The size of the sample ranged between 3 to 6 ml. The formula sample was transferred into a 7 ml Sterilin bottle. The sample was labelled with the following information: the subject ID code; with 'a' or 'b' added to identify the first (a) or second (b) feed; the date and time of feed; and finally the manufacturer and brand of the milk.

Information was recorded about the type of teat the infant used, the manufacturer, brand, flow rate and whether it was made of silicone or rubber. A summary of the types of teat used can be found in appendix 12. The experimenter asked the mother to show her the box/tin of formula milk that she used. The experimenter recorded the manufacturer, brand, whether it was derived from cows' or soya milk and the manufacturers' sodium content per 100 ml of reconstituted formula. Details of the analysis of formula milk can be found in chapter four.

The feeding bottle was weighed. The mother fed her infant in the usual way while a camcorder was focussed on the infant's mouth to video record the sucking behaviour. Once the feed was over, the camera was turned off and the feeding bottle was weighed again to determine how much milk had been consumed. The experimenter returned to the home later in the day to observe the next feed. For the second feed the procedure was repeated, except that the length and weight of the infant were not recorded. Finally, the feeding diary was collected. Milk samples were frozen on the day of study, and stored at -20°C . Table 2.4 b shows a summary of the data collected for bottle fed infants.

Table 2.4 b **Summary of data collected for bottle fed infants**

<i>Feed</i>	<i>Data collected</i>
First	Naked weight (prior to feed) Length (prior to feed) Dressed weight (prior to feed) Formula milk sample Formula milk manufacturer and brand Teat size, manufacturer and brand Weight of bottle (prior to feed) Weight of bottle (after feed)
Second	Formula milk sample Formula milk manufacturer and brand Teat size, manufacturer and brand Weight of bottle (prior to feed) Weight of bottle (after feed) Feeding diary

2.5 Analysis

Given that the data collected from this study was detailed and came in many different forms, the analysis was carefully planned with specific questions to be asked. The Millennium Baby Study had a large detailed database that contained information about all of the subjects in the research program. For the purpose of studying of feeding and growth in failure to thrive and control infants, the experimenter extracted data necessary for the study. To ensure this was done efficiently, without data being lost, each subject's identity was checked and verified each time more information became available (i.e. from incoming questionnaires, and milk sample data). Table 2.5a shows a summary of the information that was analysed in the study. The table also shows the data collected at follow up together with the information at time of follow up. In the sections that follow, details are provided about how each type of data was analysed.

Table 2.5a**Summary of information analysed in the study**

Information	Source
Routinely Collected	
Growth Data:	
Birth weight	Recruitment questionnaire
Six week weight	Six week questionnaire
Eight-twelve week weight	Observational feeding study
Four month weight	Four month questionnaire
Eight month weight	Eight month questionnaire
Twelve month weight	Twelve month questionnaire
Familial characteristics:	Section D of the recruitment questionnaire
Mothers' reports of milk feeds:	Sections A and C from the six week questionnaire
Feeding and growth data:	Observational feeding study at eight-twelve weeks – series of measurements taken to record infant feeding behaviour
Weight (kg)	
Length (cm)	
Sucking behaviour during two feeds	
Mass of milk consumed during two feeds	
Formula/teat info used at each of the two feeds	

2.5.1 Growth data

During the course of the Millennium Baby Study, the weights of the infants were collected. All of the weights were entered into a database. The particular weight information that was of relevance to this thesis was: birth weight, 6 week weight, 4 month weight and 12 month weight. Each of these data points coincided with routine health checks.

Table 2.5a outlined the source for each data point for the growth database. The birth weight and weight at 6 weeks enabled cases and controls to be selected using the Thrive Index. From the identification of cases (n=75) and controls (n=72) at six weeks, the growth of these infants was monitored during the first year. The Thrive Index was used to measure infant growth changes to four months and twelve months. For the purpose of this thesis, the following question was asked. *How do cases and controls identified at six weeks grow over the first year?*

In order to answer this question, the two groups were monitored at four months and twelve months. From this analysis it was possible to determine which infants continue to fail to thrive at four months and one year of age, and which infants recover. It was also possible to identify controls that became cases later during the first year.

When analysing the four month and twelve month data, the aim was to determine which infants were still failing to thrive. Section 2.2.1 described this procedure. As shown there the formulae for calculating identifying cases and controls at six weeks was:

For females:

Average z score at six weeks = $0.152 + 0.676$ (birth weight z score)

For males:

Average z score at six weeks = $0.046 + 0.714$ (birth weight z score)

To calculate the Thrive Index for each infant:

Thrive Index = Average z score six weeks – actual z score six weeks

A threshold of -0.803 for females and -0.871 for males identified cases whose Thrive Index was less than these values and controls that were greater than these values. To investigate the growth of infants to twelve months, a similar procedure was used. Firstly average weight gain to twelve months was predicted:

For females and males:

Average twelve month z score = 0.4 (birth weight z score)

The Thrive Index was calculated:

Thrive Index = average twelve month weight – actual twelve month weight

Once the Thrive Index was calculated for all infants in the cohort, the value for the 10th percentile was found. For twelve months the threshold for identifying failure to thrive cases was 1.3. All infants with a Thrive Index of less than 1.3 were identified as cases at twelve months i.e. below the 10th percentile.



2.5.2 Familial characteristics

Details of the familial characteristics of the case and control infants originated from the data in section D of the recruitment questionnaire. The familial characteristics of the case and control infants is important since previous research has found that families of cases and controls differ on a number of different points. The previous chapter discussed these differences in detail, but to briefly summarise the main points: research has found evidence that mothers of case infants are less likely to have finished school (Kotelchuck & Newberger, 1983; Singer et al, 1990); cases are more common amongst inner-city deprived populations (Dowdney et al, 1987; Wright et al, 1994b). By examining the data from the recruitment questionnaire, it was possible to determine if there were any differences between our case and control families. The specific question asked was: *Do the families of cases differ from the families of controls?*

The data from section D of the recruitment questionnaire asked mothers to provide information about their highest level of educational attainment; house/car ownership; number of wage earners in the household; number of previous children and religious affiliation. Chapter 3 presents the results of the analysis of this data. The families of case and control infants were compared on each of these above mentioned variables, and a series of analyses conducted to test for differences between the case and control families.

2.5.3 Mothers' reports of milk feeds

The source of this information was sections A and C of the six week questionnaire. The mothers' reports of the milk feeds in her infant are important for a number of reasons. Firstly, the details the mothers provided occurred at a time when the weight gain of the infant had just been determined using the Thrive Index. Therefore the details provided would give evidence concerning the early feeding behaviour of cases and controls as perceived by the mother. Secondly, the questionnaire was completed a few weeks prior to the observational feeding study, in which an experimenter recorded the feeding behaviour of infants. This allowed a comparison between objectively recorded and reported data.

In order to answer the question,

Do mothers of cases report more feeding problems than mothers of controls?

the data from sections A and C were analysed. The analyses of these sections are presented in Chapter Five. Comparisons between case and control infants were made to examine differences between the two groups.

2.5.4 Observational data

The video records of breast and bottle fed infants were both coded using the same method. A computer program 'Minkey' (Marsh, 1988) was used to code the videos. The program was devised to aid observational research by allowing an experimenter to record behaviour using a portable computer in the field. In this research, the program was run simultaneously with the video of the infants' sucking behaviour. The

experimenter manually input the data using keys to code the observed behaviour. These different behaviours and the coded keys used are summarised in table 2.5.4a.

Table 2.5.4a. Summary of type commands for Minkey

<i>Type command</i>		<i>Behaviour</i>
Mother	q	Milk
	u	Bottle
	Y	Breast
	a	Give teat/ nipple
	y	Take off
Infant	z	Left breast, suck
	v	Right breast, suck
	z or v	Bottle, suck
	m	Invisible
	n	Visible
	k	Release nipple/ teat from mouth
	j	Reject nipple/teat from mouth

Each behaviour had a corresponding key. By pressing the key, the observation was recorded on a time sequence that was accurate to 10 milliseconds. To code a video of the feeding episode, the Minkey program was opened and the subject's identity number was entered. There were two identifiers used for each subject. Firstly, the mother's name, abbreviated (e.g. Jane Smith became JSM). Secondly, the number corresponded

to the number issued by the Millennium Baby Study administration. The program required a cue of either Y (breast) or u (bottle) to denote the feed type. The giving of the breast or bottle was recorded (a) and then the infant's sucking; each individual suck was recorded (as v or z). The 'visible' and 'invisible' keys were used (w, n) to record when the infant's mouth became obscured, due to the infant turning their head or the mother inadvertently moving the infant out of the view of the camera. The mother may take the infant off the breast or bottle for winding or to adjust the feeding posture (y). Towards the end of the feed, the infant may refuse the breast or bottle (j). Throughout the feed the infant may release the teat or nipple (k) the mother's response to offer it again, was also recorded (a).

Once the feed had been coded, the program was ended and the results saved. The program saved the results into a '.obs' file. The prefix to the '.obs' was the subject's identity code, for example *JSM0123a.obs*. The *JSM* denoted the mother's name *Jane Smith*, the '*0123*' denoted the number within the 1000 infants within the Millennium Baby Study database, and finally the '*a*' represented the feed being studied; '*a*' for the first feed and '*b*' for the second feed. The observational file for the second feed for the same subject would read '*JSM0123b.obs*'. This coding system allowed consistency and accurate data recording for all of the feeds studied, and the two feeds for each subject could easily be identified.

The statistical program SPSS is unable to read the '.obs' files directly, so each file was converted into a format that SPSS could read. SPSS was used to calculate the intervals between behaviour codes for further analyses. The intervals were analysed in S+ using a mixture model (Chetwynd et al, 1998) as discussed in more detail in Chapter Five.

The sucking behaviour of the infants was summarised into the following feeding parameter estimates:

Mean sucks per burst at the start of the feed

Mean sucks per burst at the end of the feed

Mean suck duration start of the feed

Mean suck duration at the end of the feed

Mean suck duration, sd at the start of the feed

Mean suck duration, sd at the end of the feed

Mean pause length at the start of the feed

Mean pause length at the end of the feed

From these estimates it was possible to examine differences between cases and controls.

A series of t-tests were used to compare the two groups. The results of this data are presented in Chapter Five. The mass of milk consumed and the duration of feeds is also compared in Chapter Five.

2.5.5 Formula milk samples

At the home visits when the infants were eight to twelve weeks of age, samples of the prepared formula milk were taken prior to bottle feeds to assess mothers' accuracy at reconstituting formula milk. Prior to each observed bottle feed, a sample of formula milk was collected using sterile syringes and stored in sterilin pots that were frozen on the day of collection, in a secure laboratory at Durham University. The procedure enabled two samples to be taken for each subject, because two feeds were being

recorded. The samples were coded in an identical way to the 'obs' files described above. For example, 'JSM0123a' denoted 'first feed for Jane Smith identity number 123' and 'JSM0123b' denoted 'second feed for Jane Smith identity number 123'. The small pots were labelled with the ID string, plus the date, time of feed, and the manufacturers' brand (e.g. SMA Gold). A database was also created to store a record of all the samples that had been collected, and all of the written material on each pot. Finally, the database contained details of the manufacturers' sodium content for each brand. A summary of the brands used by mothers and the manufacturers' guidelines can be found in appendix 14. The analyses of samples was carried out by Dr. Chris Seal, a nutritional biochemist in the Department of Agriculture, Newcastle University.

The analysis conducted at Newcastle University compared mother's reconstitution of formula milk, with the accurate reconstitution of formula milk. Each of the main brands of formula milk used by the mothers (see appendix 9) was purchased and reconstituted by carefully weighing the dried matter and measuring the water that was added according to manufacturers' instructions. These reconstituted formulas were compared with the samples collected from the mothers.

The analysis was conducted by selecting one particular brand and analysing all of the milk samples for that particular brand at the same time, for example, all milk samples that were reconstituted from Cow and Gate Premium. Each milk sample was defrosted and 1 ml of formula was extracted in duplicate and placed into pre-dried and weighed porcelain crucibles. These crucibles were oven dried for 20 hours in a fan oven set at 70 °C. The crucibles were then cooled in desiccators. The weight of the dried matter plus the crucible was measured. The proportion of dry matter within each crucible was determined using the following formula:

$$\frac{(\text{weight of dry matter} + \text{crucible}) - (\text{weight of crucible})}{(\text{weight of milk} + \text{crucible}) - (\text{weight of crucible})}$$

The proportion of dried matter in the mothers' reconstituted formula was compared to that in the laboratory reconstituted formula of the same brand. Each branded formula was reconstituted three times within the laboratory, and analysed four times to ensure the reliability of the findings.

The data obtained from this analysis showed the percentage of dried matter per sample for each infants' feed. The accuracy of the mothers' reconstituted feeds were determined by comparing them with the properly reconstituted feeds. By conducting correlation tests, the similarity of reconstituted milk for each of the infant's two feeds was determined. A prediction was that the reconstituted formula by case mothers would be more dilute and inconsistent from one feed to the next.

2.6 Summary

This chapter has outlined the methods used in the research reported in this thesis. There were 75 cases and 72 controls, studied on a number of different measures. Their growth was assessed to twelve months using the Thrive Index. Data on their feeding behaviour was collected from a feeding questionnaire sent to mothers when the infant was six weeks of age. Observational feeding data was collected from a study when the infant was aged between eight and twelve weeks. This observational study recorded the

sucking behaviour of infants and milk samples were collected to assess the accuracy of mothers' reconstitution of formula milk.

Chapter Three examines the study sample more closely. The birth weight and six week weight for case and control infants are presented. This chapter also analyses the data about the families obtained from the recruitment questionnaire. Chapters Four and Five present the analyses of the feeding data. Chapter Four analyses the data obtained on the sucking behaviour, milk consumed and the reconstitution of formula milk. Chapter Five presents the data from the six week feeding questionnaire. Differences and similarities between mothers of cases and mothers of controls are examined. Finally, Chapter Six examines the growth data in more detail. The growth of the infants to twelve months is examined.

Chapter 3:

**The study sample: Weight gain
and the characteristics of the
families.**

Chapter Three

The study sample: weight gain and the characteristics of the families

3.1 The identification of failure to thrive

This chapter is divided into two main sections. The first section examines the weight gain of infant girls and boys from birth to six weeks and the selection criteria for identifying cases and controls. The second section analyses family characteristics of the cases and controls.

The previous chapter described the procedure used for selecting cases and controls and monitoring their growth (refer to section 2.2.1). Figures 3.1 and 3.2 show birth weight and six week weights, for females and males respectively. There are two lines plotted on each graph. One is labelled 'average', the other 'threshold'. The 'average' line represents the weight of an infant with average weight gain to six weeks, given the birth weight, calculated using the formula given above. The 'threshold' line is the threshold for identifying the slowest growing 10% of infants. For females, this line is 0.803 z below the 'average' line. For males, the 'threshold' line is 0.871 z below the 'average' line.

The 'average' line is useful since children of an unselected population are distributed either side of this line. In other words we would expect to find controls below this line, because although their weight gain is below average, they are not among the slowest

growing 10%. The 'threshold' line identifies the slowest growing 10%, and consequently, all the cases fall below this line.

To give examples, a female case infant with a birth weight z score of 2.36 had a six week z score of 0.42. Another female infant, with about the same birth weight (2.35) had a six week z score of 1.12. The predicted six week z score for these infants is 1.74. To calculate the thrive index for each infant, the difference between the predicted z score and the actual six week z score is calculated; this is -1.32 for the first infant, and -0.62 for the second infant. The first infant is identified as a case, since their thrive index is less than -0.803 . The second infant is a control, since their thrive index is greater than -0.803 .

Figure 3.1 : Plot of z score for weight at six weeks against z score for weight at birth for female cases and controls.

Plot of z score for weight at six weeks against z score for weight at birth. The average line is the best fitting line for the linear regression of the latter on the earlier z score. The threshold line is set 0.803 z below the average line, and identifies the slowest growing 10%. Controls are above this line, and cases all below.

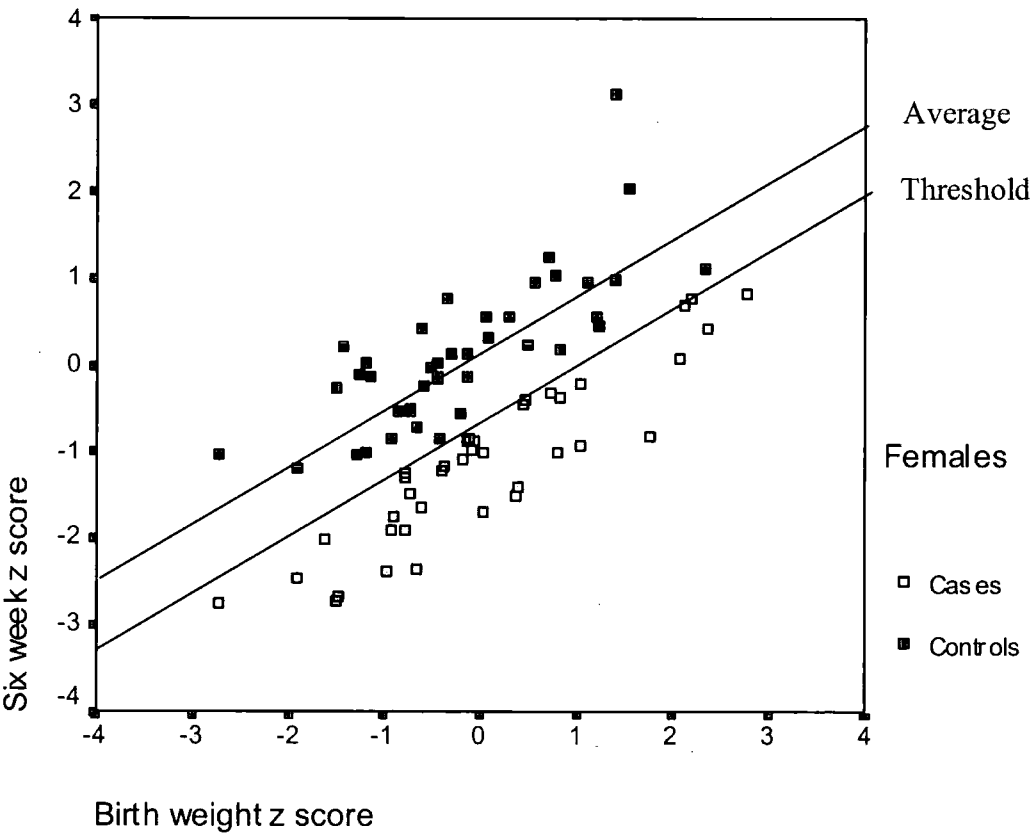
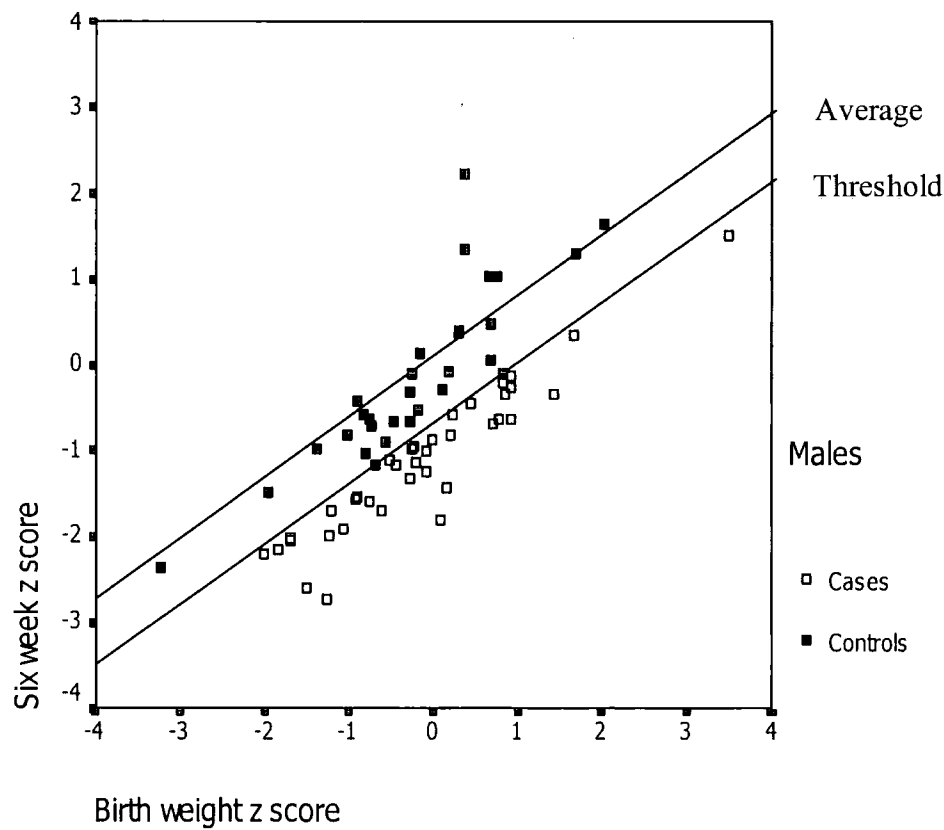


Figure 3.2 Plot of z score for weight at six weeks against z score for weight at birth for male cases and controls.

The average line is the best fitting line for the linear regression of the latter on the earlier z score. The threshold line is set 0.871 z below the average line, and identifies the slowest growing 10%. Controls are above this line, and cases all below.



As a result of the selection, 147 subjects were identified for study from the 1000 birth cohort. The case subjects were selected using the Thrive Index, and controls were randomly selected thereafter as explained in Chapter Two. Of these 147 subjects, there were 75 cases and 72 controls. Observational feeding behaviour was obtained for 19 cases and 30 controls. Table 3.1a shows a summary of this information.

<div> <div>Table 3.1a</div> <div>Number of subjects studied within each group.</div> </div>			
	<i>N=</i>	<i>Cases</i>	<i>Controls</i>
Millennium Baby Study	147	75	72
Observational Data Collected	49	19	30

Figure 3.3 shows the female distribution of z scores at birth and six weeks for cases and controls. Figure 3.4 shows the male distribution of z scores at birth weight and six weeks for cases and controls. The distributions of z scores is approximately normal, and differences between cases and controls can be examined using a t-test. Table 3.1d shows the t test results for the birth weight analysis and table 3.1e shows the results for the six week weight analysis.

Figure 3.3 Distribution of birth weight and six week z scores for females cases and controls

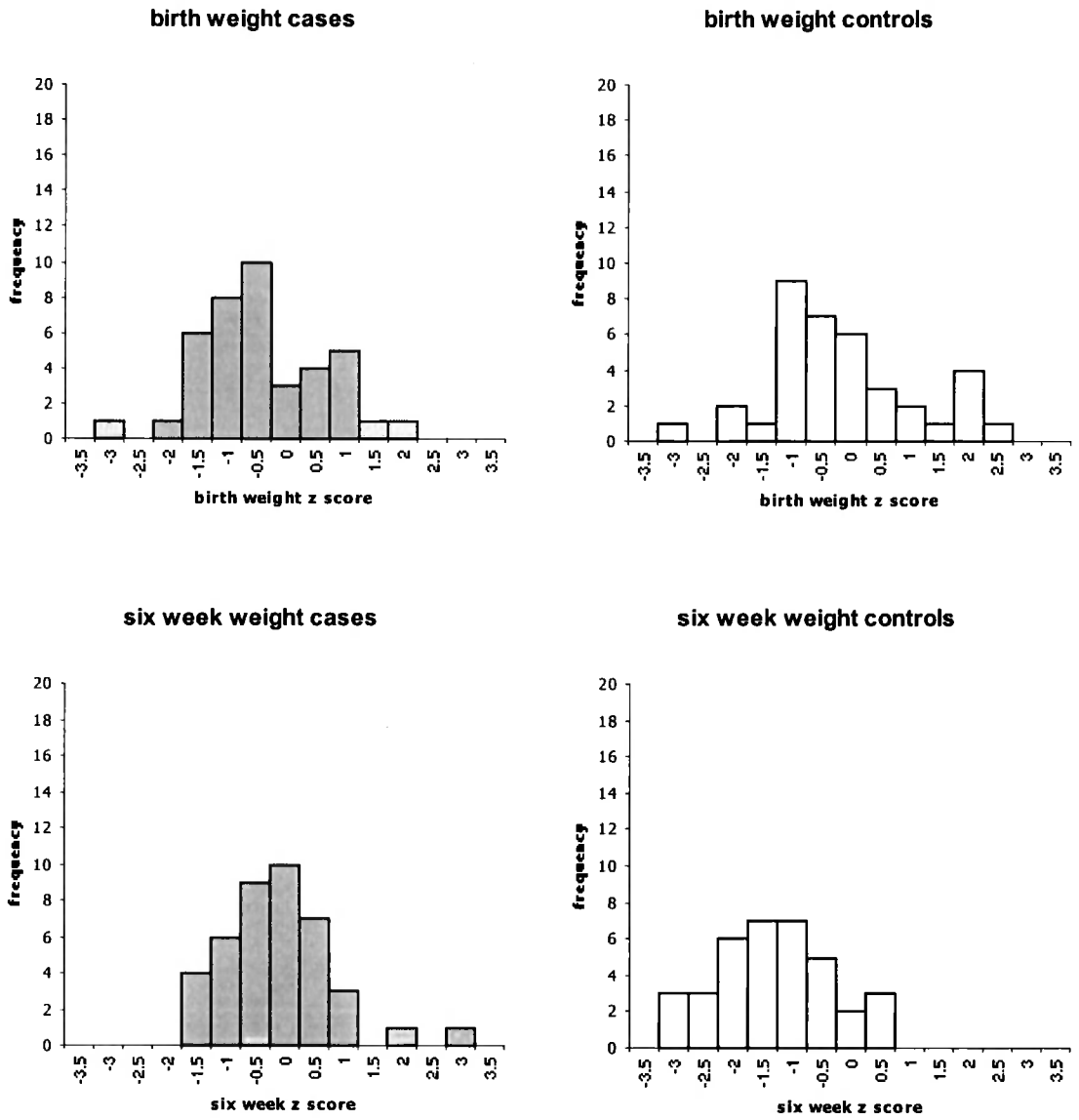


Figure 3.4 Distribution of birth weight and six week z scores for male cases and controls

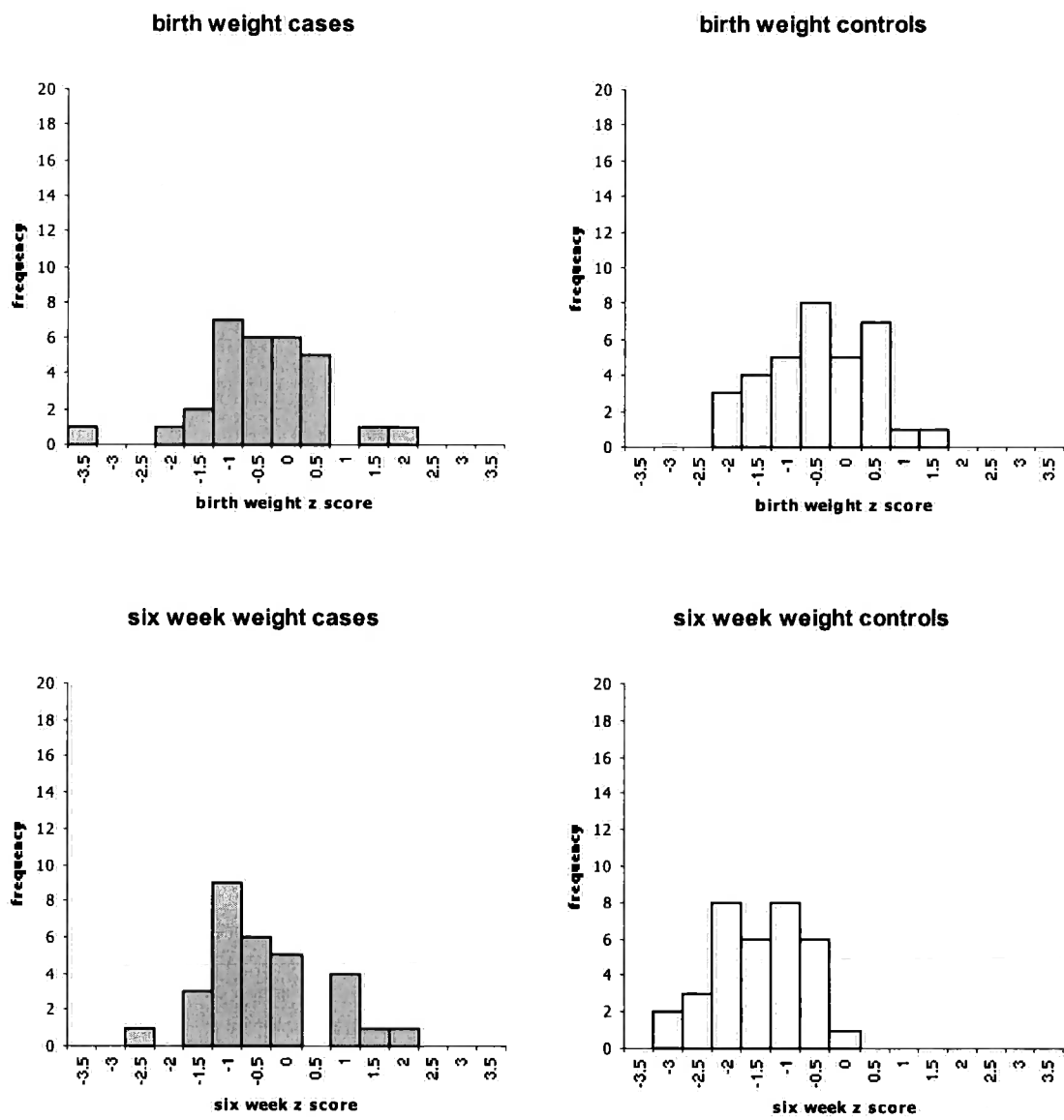


Table 3.1b shows the mean and standard deviation for birth weight and six week weight for cases and controls. There was no statistically significant difference between birth weight of cases and controls ($t = -.47$, $df = 145$, $p = 0.64$). But there was at six weeks ($t = 6.23$, $df = 145$, $p = 0.00$). This means that the procedure used adjusts for Birth weight, so although the six week weight differs between cases and controls, Birth weight does not.

Table 3.1b		Mean and standard deviation for birth and six week weight for cases and controls			
	t	Birth		Six weeks	
		SD		t	SD
Cases (n=75)	3.45	.58		4.16	.56
Controls (n=72)	3.41	.49		4.79	.68

3.2 Comparing the familial characteristics of case and control infants

Reported features of the ‘failure to thrive home’ are: impoverished and overcrowded homes (Dubowitz, 1989); absence of extended family (Bithoney & Newberger, 1987; Bithoney & Rathburn, 1983; Pollit & Leibel, 1980) unemployment (Bruerilin et al 1983), and lower educational attainment of mothers (Kotelchuck & Newberger, 1983).

However, there have also been studies that have compared cases with controls and found no differences between the home environments of cases and controls infants (Altemier et al, 1985; Bithoney & Newberger, 1987). The conclusion reached in research conducted on the home environment is dependent upon the sample selected and the comparison group. To fully understand the family characteristics of case infants, research needs to screen an entire community rather than use a referred sample. Hospitalised infants are a small group of extreme cases of failure to thrive, and are not representative of all cases of failure to thrive. Another research issue is to supply an appropriate control group. The cases must be selected from all sectors of a population and not restricted to one particular social class.

The familial characteristics were recorded through a questionnaire at the time the mother and infant were recruited to the study i.e. soon after the infant was born. The specific questions asked of the data about the families was whether case infant homes differed from control infant homes.

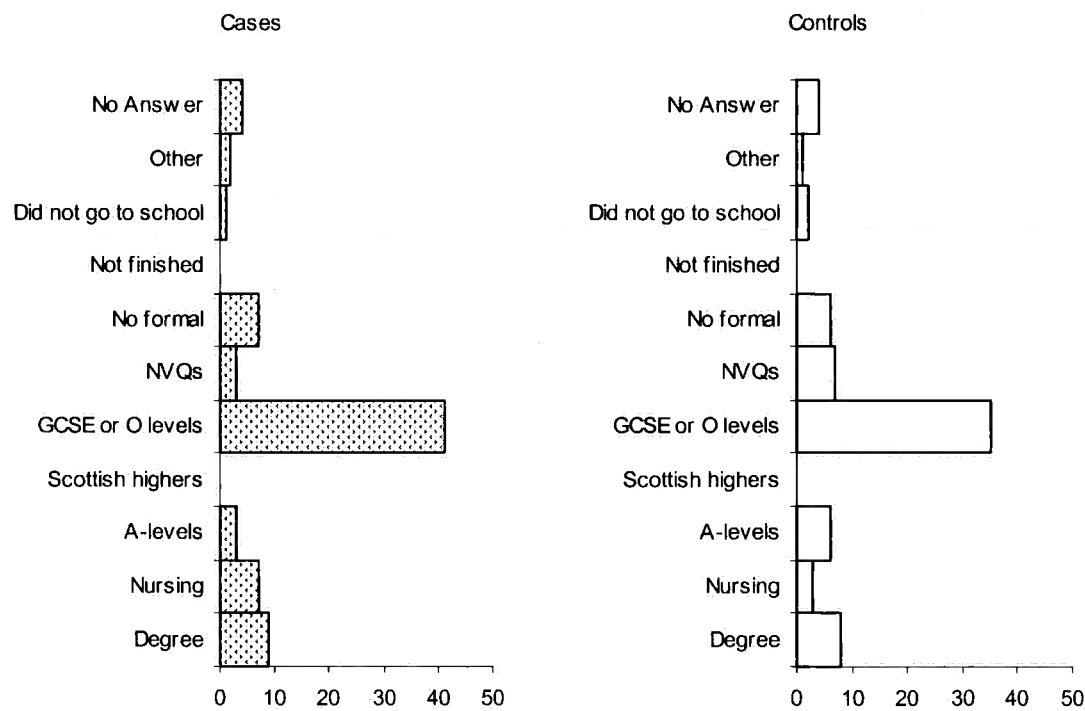
Information about the familial characteristics of cases and controls was obtained from the recruitment questionnaire given to all mothers who participated in the study. Section D of the questionnaire (see appendix four), asked mothers to provide information about their social circumstances. The type of information included maternal education, number of wage earners in the household, home and car ownership, number of previous children. The religious affiliation was recorded on the Recruitment Form (see appendix 4). During the course of this section, the responses of mothers of cases and controls to each of the relevant questions is summarised.

3.2.1 Maternal education

Mothers were asked to state the highest level of their educational attainment. Figure 3.5 shows a summary of the frequency of mothers' responses for this question.

Figure 3.5 Maternal qualifications in cases and controls

Educational attainment *for cases* (n=75) controls (n=72) is shown on the y axis and the frequency is shown on the x axis. The figure shows that the majority of responses are centred on the high school qualifications with fewer mothers of both cases and controls achieving higher qualifications.



The responses ‘NVQ’, ‘G.C.S.E / O-Level’ were collapsed into one category and the categories for ‘Scottish Higher’, ‘A-Level’, ‘Nursing’ and ‘Degree’ were similarly collapsed into another category. The category of ‘no formal’ provided a third category. The other responses ‘Not finished’, ‘Did Not Go To School’, ‘Other’ and ‘No Answer’ were excluded from the analysis. By condensing the responses in this way, the analysis would show a distinction between mothers who had left school at 16, and those that had continued their education beyond high school. A chi square analysis was conducted on these two categories of responses i.e. left school at 16 and higher education. The results of the analysis are shown in table 3.2.1. The table shows that there was no statistically significant difference between mothers of cases and mothers of controls in terms of the highest educational level of achievement.

Table 3.2.1 Maternal educational attainment of cases and controls

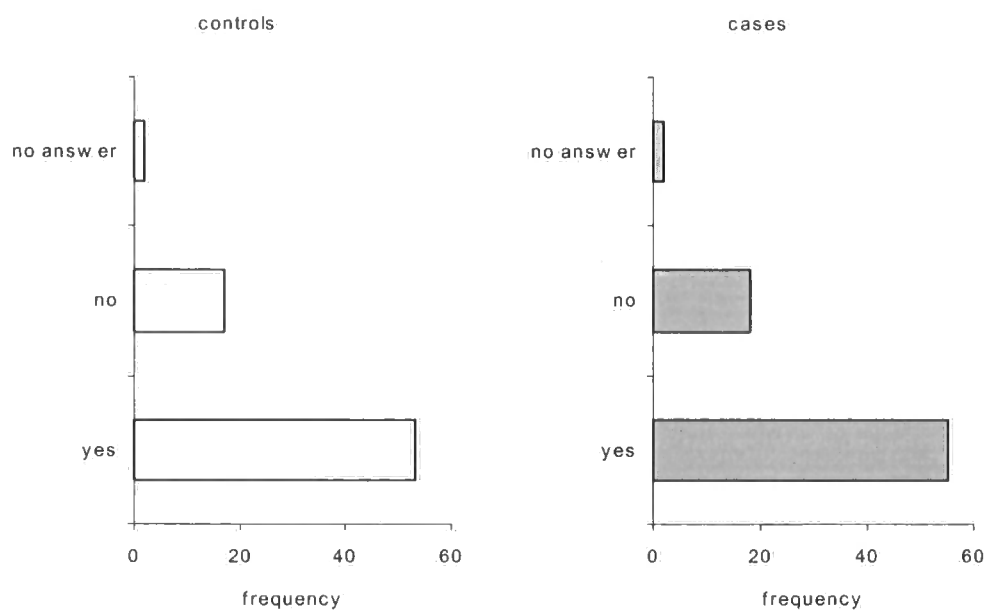
	Cases	Controls
Further education	44	38
Higher education	17	17
No formal	7	9
chi-square value	.57	
Df	2	
P (two tailed)	.75	

3.2.2 Wage earning in the household

Mothers were asked whether there was one or more wages coming into the household. Figure 3.6 shows the mothers responses. The 55 (73.3%) of mothers of cases and 53 controls (73.6%) had one or more wage in their household (i.e. ‘Yes’).

Figure 3.6 Wage earning in cases and controls

Details of wage earning in control families (left of page) and case families (right of page). The ‘Yes’ response indicates that there is one or more wage coming into the household; ‘No’ indicates no wage coming into the household; and finally ‘No answer’ indicates that some mothers preferred not to give any details on this question.



The possible answers a mother could choose from were ‘Yes’ or ‘No’. The ‘Yes’ and ‘No’ responses were analysed and a summary can be found in table 3.2.2 The table shows the results of the chi-square analysis for wage earning in the household. There was no significant difference between cases and controls families on the wage earning criteria.

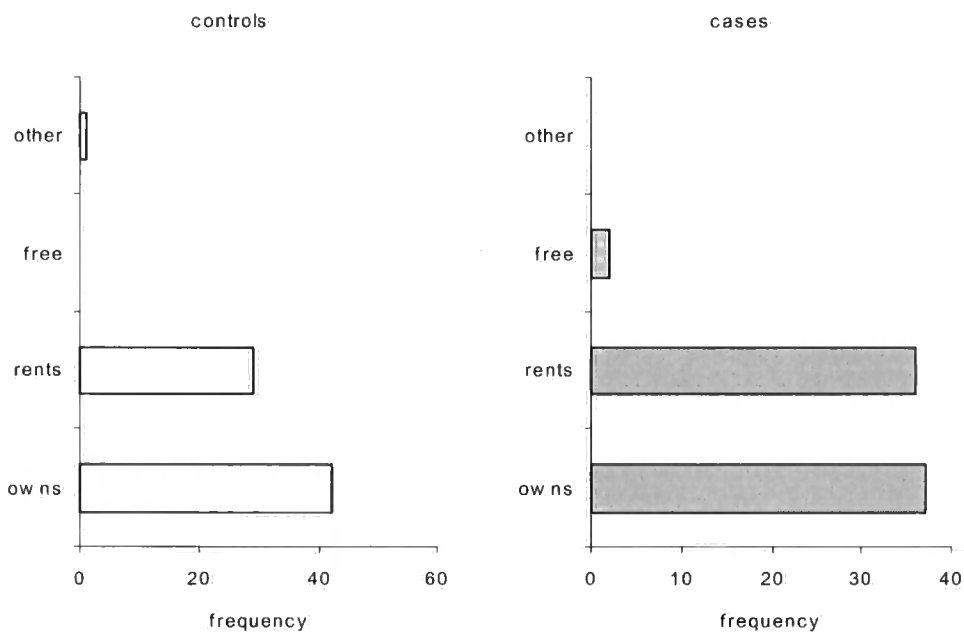
<hr/>		
Table 3.2.2	Wage earning in cases and controls	
	Cases	Controls
Yes	55	53
No	18	17
chi-square value	.00	
Df	1	
P (two tailed)	.96	
<hr/>		

3.2.3 House ownership

Mothers were asked about home ownership. Figure 3.7 shows the frequency data for the responses of mothers of cases and controls. More mothers own their own home, but there are a large number of mothers who rent their accommodation.

Figure 3.7 House Ownership in cases and controls

The y axis indicates the response and the x axis is its frequency.



To analyse the data, the categories of ‘Rents’ and ‘Rent free’ were collapsed into one category and compared with the category ‘Owns with mortgage’. The category of ‘Other’ was excluded. This analysis would make the distinction between home ownership and non home ownership. Table 3.2.3 shows the results of the analysis for case and control comparisons on home ownership. There was no statistically significant difference between the families of cases and controls.

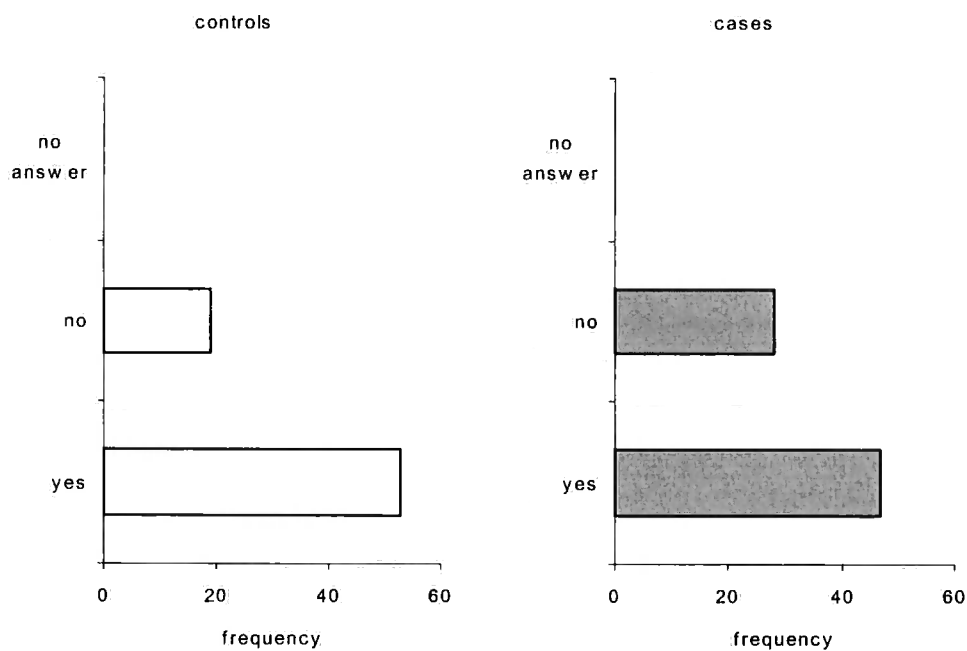
<hr/>		
Table 3.2.3	Home ownership in cases and controls	
	Cases	Controls
Rent/ rent free	37	38
Own with mortgage	38	32
chi-square value	.36	
Df	1	
P (two tailed)	.55	
<hr/>		

3.2.4 Car ownership

Mothers were asked if anyone in their household own a car. Figure 3.8 shows a summary of the responses. The majority of mothers of both cases and controls own a car.

Figure 3.8 Car ownership in cases and controls

The y axis indicates the response and the x axis is the frequency of the response for the selected group.



The possible answers they could make were 'Yes' or 'No'. To analyse the data, a comparison was made between owning a car and not owning a car. 'No answer' category was excluded. Table 3.2.4 shows the results. The table shows that there was statistically no significant difference between the responses made by the mothers of cases and controls on this question .

Table 3.2.4 **Car ownership in cases and controls**

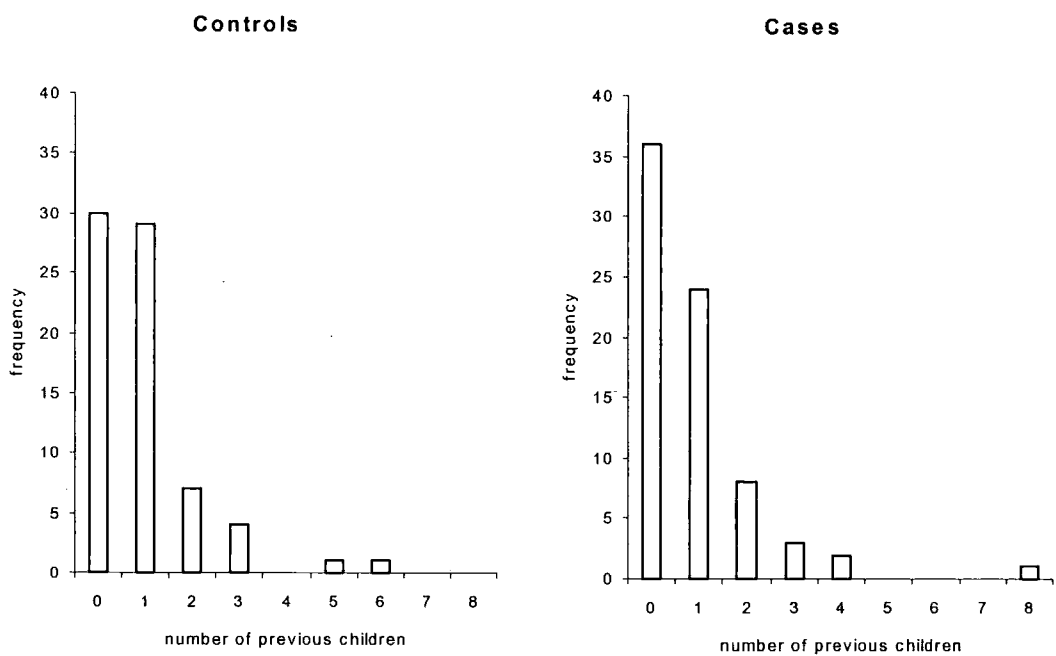
	Cases	Controls
Owens a car	47	44
Does not own car	28	28
chi-square value,	.04	
Df	1	
P (two tailed)	.85	

3.2.5 Number of previous children

Mothers were asked to state how many previous children there were in the household. Figure 3.9 shows a summary of the responses made by mothers of cases and controls. The figure shows that the majority of mothers have only 1 or no other children in their household.

Figure 3.9 Number of previous children in cases and controls

The y axis indicates the frequency and the x axis is the number of previous children for the selected group. The column labelled ‘8’ refers to 8 or more.



Mothers were asked to state how many previous children they had. To analyse the answers a Mann-Whitney U test was used to investigate group differences, since the data was ordinal and was not normally distributed. The results of the analysis together with the median, first and third quartile are shown in table 3.2.5. The results show that there was no statistically significant difference between cases and controls on the number of previous children in the household

Table 3.2.5 **Number of previous children in cases and control families**

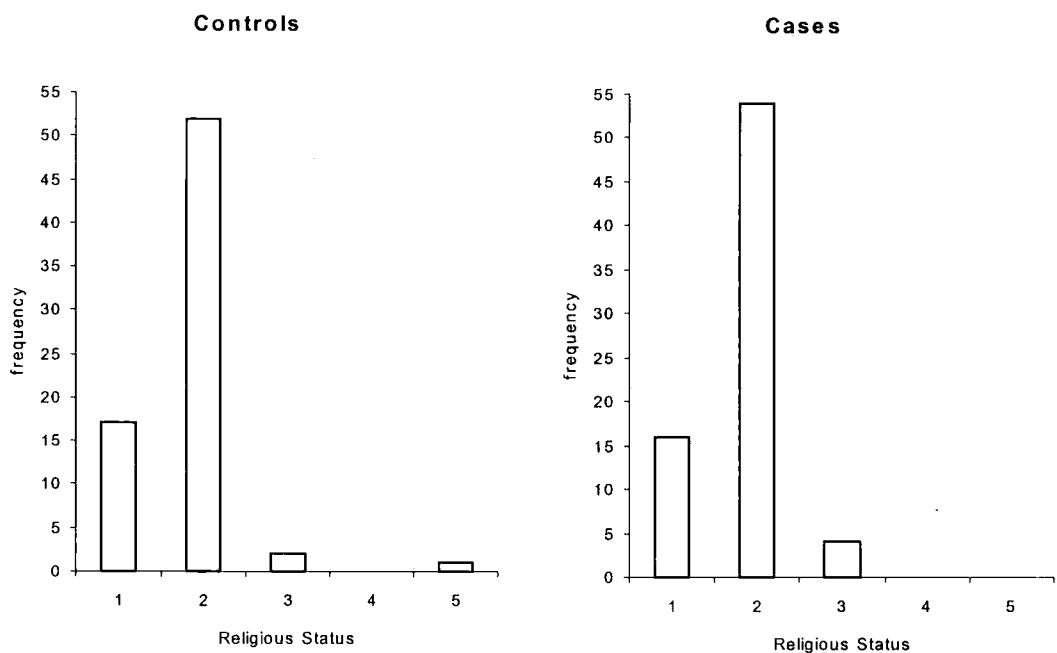
	Cases	Controls
First quartile	0	0
Median	1	1
Third quartile	1	1
Z	-.59	
N	147	
P (two tailed)	.55	

3.2.6 Religious affiliation

Mothers were asked to state their religious affiliation on the recruitment form (see appendix 4). Figure 3.10 shows a summary of the responses. The figure shows that the majority of mothers are of Christian affiliation. The next large majority of responses is for 'none'.

Figure 3.10 Details of religious status in cases and controls

Details of religious affiliation of the families of cases and controls. The y axis indicates the frequency and the x axis is the religious status. 1= None, 2= Christian, 3=Orthodox Jewish, 4= Jewish non orthodox , 5= other.



The possible choice of response they could make was ‘None’, ‘Christian’, ‘Orthodox Jewish’, ‘Jewish (non orthodox)’ and ‘Other’. For the purpose of analysis, the categories of ‘Orthodox Jewish’, ‘other’ and ‘Jewish’ were collapsed and compared to the categories of ‘none’ and ‘Christian’. Table 3.2.6 shows the results of a chi-square analysis examining the differences between responses made by mothers of cases and controls. The table shows that there was no statistically significant difference between case and control families in terms of religious affiliation.

Table 3.2.6 Religious affiliation in cases and controls		
	Cases	Controls
None	16	17
Christian	54	52
Jewish and other	4	3
chi-square value,	.18	
Df	2	
P (two tailed)	.91	

3.2.7 Summary

This section has examined the family characteristics of case and control families. The families were compared on maternal education, wage earning, house ownership, car ownership, number of previous children and religious affiliation. The case and control families did not differ from each other statistically on any of these categories.

Therefore, the cases and controls did not differ in any major socio-economic characteristic.

3.3 Comparison of the familial characteristics of infants followed up and infants not followed up between eight and twelve weeks

The observational study was carried out when the infants were aged between eight and twelve weeks of age. The observational study involved observing two consecutive feeds in case and control infants. All mothers of the cases (n=75) and controls (n=72) were invited to participate, however a number refused or were unavailable at the time of follow up (see ‘Attrition’ in Chapter 2). There were 19 cases and 30 controls studied at the time of follow up and this section compares the familial characteristics of the families followed up (n=49) with the families not followed up (n=98). This is a necessary part of the analysis, to determine whether the sample followed up were representative of the whole sample. The families are compared on the same characteristics as the previous section i.e. maternal education, wage earning, house and car ownership, number of previous children and religious affiliation. Table 3.3 shows the percentage of responses for each. The categories have been collapsed in the same way as the previous section.

The table shows that the only statistically significant difference between families followed up (n=49) and families not followed up (n=98) was for the number of previous children. The families of infants followed up were more likely to have larger households, i.e. more children in the family. On all other criteria, there was no statistically significant difference between the families.

Table 3.3 Frequency data for responses made by mothers of cases and controls

	<i>Followed up (%)</i>	<i>Not followed up (%)</i>
<i>Maternal Education</i>		
No formal	14	11.2
Higher education	25.6	25.8
Further education	60.5	62.9
Chi square value .21 , df 2, p (2 tailed) .90 .		
<i>Wage Earning</i>		
Yes	77.8	74.5
No	22.2	25.5
Chi square value .18 , df 1, p (2 tailed) .67 .		
<i>House ownership</i>		
Rents/rent free	52.1	51.5
Owns (with mortgage)	47.9	48.5
Chi square value .00 , df 1, p (2 tailed) .95.		
<i>Car ownership</i>		
Yes	61.2	62.2
No	38.8	37.8
Chi square value .01, df 1, p (2 tailed) .90.		
<i>Number of previous children (not shown as %)</i>		
First quartile	0	0
Median	1	0.5
Third quartile	1	1
Z = -1.73, N= 147, p (2 tailed) .08.		
<i>Religious affiliation</i>		
None	14.6	26.5
Christian	77.1	70.4
Jewish or other	8.3	3.1
Chi square value 4.1, df 2, p (2 tailed) .13.		

The analysis regarding number of previous children showed a p value of .08. The effect size was calculated to see if the data within the distributions was driving the trend in the data. The effect size analysis showed a result of $r = .14$, this was a small effect and suggested that there was no practical significance to the trend. For .8 power a sample size of over 310 would have been required (Cohen, 1988).

3.4 Summary

This chapter has examined closely two important features of the selected sample from the Millennium Baby Study cohort. The first was weight gain, and the second familial characteristics. Weight gain was studied from birth to six weeks. The six week weight, but not birth weight differed significantly in cases and controls.

The families of case and control infants did not differ from each other statistically on any of the analysed characteristics.

The next chapter examines the feeding data collected when the infants were followed up between eight to twelve weeks of age. The weight gain of cases and controls to six weeks were different from each other. A selection of these infants were followed up between eight and twelve weeks and the infants' feeding is examined in the following chapter.

Chapter 4:

Analyses of feeding questionnaire data (6 weeks)

Chapter 4

Analysis of feeding questionnaire data

4.1 Introduction

The previous chapter contained details about the weight gain and familial characteristics of case and control infants. This chapter and chapter five examine the infants' feeding behaviour. Data on the feeding behaviour of case and control infants came from two main sources: the six week feeding questionnaire and the observational study. This chapter presents the feeding behaviour data from the six week feeding questionnaire completed by the caregiver. Chapter five describes the feeding behaviour of the infants during the observational study when the infants were aged eight to twelve weeks.

Appendix 5 contains the six week feeding questionnaire and sections A and C were analysed for this thesis. These sections were designed to collect information from the mother about the volume and duration of feeds, infant appetite, the general feeding situation for mother and infant, oral motor problems in the infant, the infants' ability to regulate their intake and the mothers' perception of her infant's body image. A group of questions was designed to collect information on each of these areas.

There were other questions related to feeding behaviour. These questions included how the infant was being fed (breast, bottle or both), whether the mother was choosing to feed her infant on demand or at set times, and the frequency of the feeds.

The first key issue was the volume and duration of the feeds. There was the possibility that mothers of cases would report either of these lower than mothers of controls. The mother's rating of her infant's appetite was important, since the mothers of cases might report a poorer appetite of their infants than controls. A series of questions was designed to collect information about the feeding situation to identify whether cases were more difficult to feed than controls. Oral motor problems are associated with failure to thrive therefore a series of questions were also devoted to this. There were also a series of questions related to the regulation of intake, for example whether vomiting was more frequent in cases than controls. Finally, there was a question related to body image. This was to determine if the reports of body image between cases and controls differed. Although there was an overall 100% response rate for all cases (n=75) and controls (n=72) some questions were not completed by the mothers and were left blank. This means that the number of missing data points for each questions is small but varies from question to question.

4.2 General feeding questions

Figure 4.1 shows a summary of the responses for cases and controls in response to: 'How is your baby being fed at the moment?'. The majority of case and control infants were bottle fed at six weeks. The graph shows that there was missing data for four control subjects and seven case subjects. The data were categorical so a chi-square test was carried out to determine if there were any statistically significant group differences. Table 4.2a shows the percentages of case and control infants being fed according to feed type and the statistical analysis. There was no statistically significant difference between cases and

controls. Therefore, when cases and controls were selected, it was evident from this questionnaire data that the feed type did not differ between the two groups.

Figure 4.1 Frequency of responses for feed type

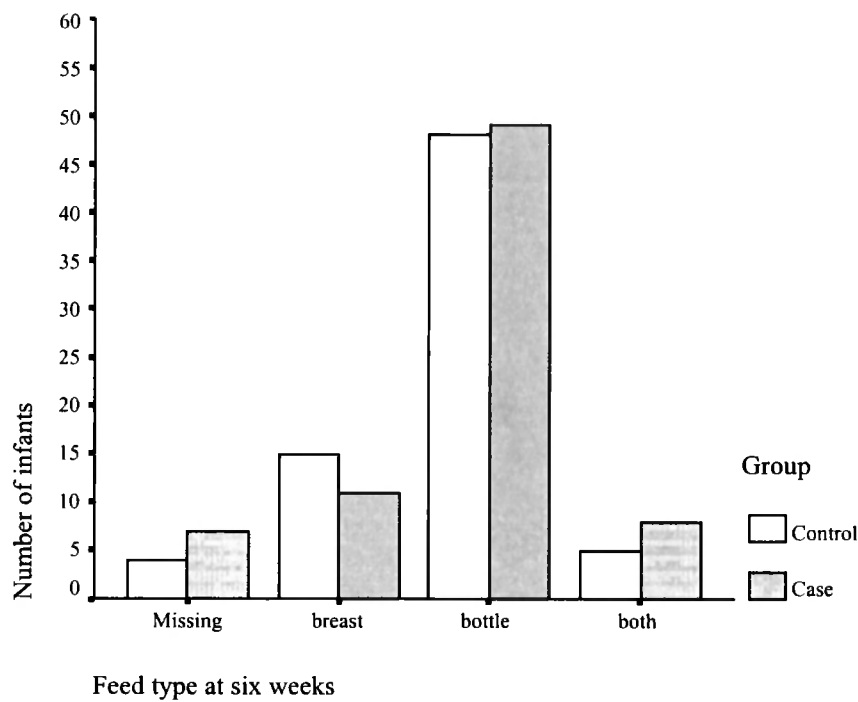
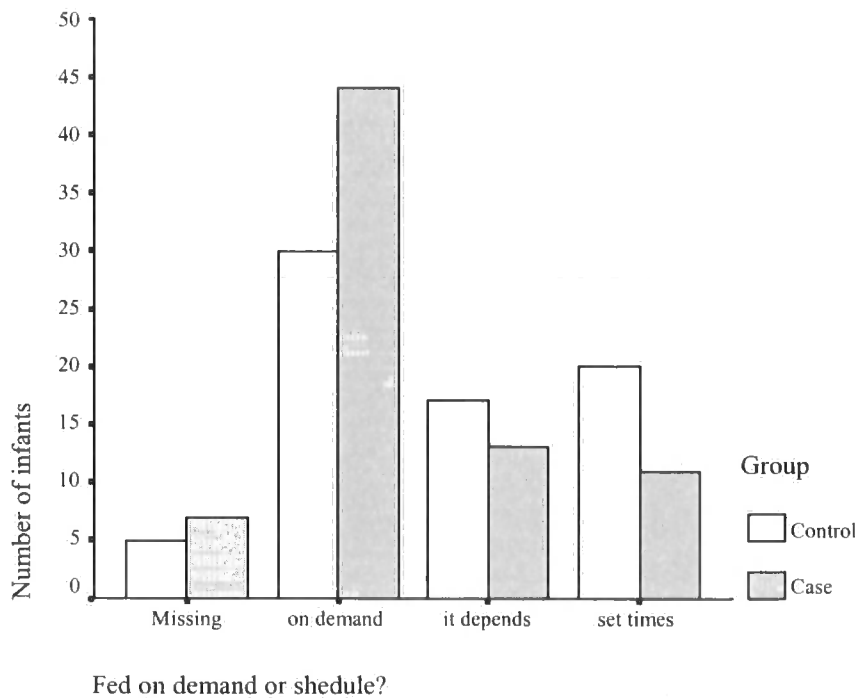


Table 4.2a Frequency of feed type within each group

Feed type	Controls (n=68)	Cases (n=68)
Breast	15 (22.1%)	11 (24.2%)
Bottle	48 (70.6%)	49 (72%)
Breast & bottle	5 (7.4%)	8 (11.8%)
Chi-square = 1.32, df = 2, p = 0.52		

The next question mothers were asked was ‘At the moment, is your baby being fed on demand or generally at set times?.’ The possibility was that mothers of cases may adopt a different feeding schedule from that used by the mothers of controls, and perhaps this difference in feeding schedule may help to explain the difference in the weight gain of the two groups. The response data were categorical and the options for responding were ‘Fed on demand’, ‘It depends’ and ‘Generally set times’. Figure 4.2 shows a frequency of responses for cases and controls. There was missing data for five controls and seven cases. There figure also shows that there are more case infants being fed on demand than controls. The category of ‘It depends’ was omitted from the statistical analysis which can be found in table 4.2b.

Figure 4.2 Frequency of feeding schedule



A chi-square was used to analyse the data statistically and Table 4.2b shows a summary of the results. The results show a significant difference between cases and controls ($p=0.025$). The data shows that there is a trend for cases to be fed on demand whereas controls at this age are more likely to be feeding at set times. The implications of these results will be discussed in more detail in Chapter Seven.

Table 4.2b Frequency of feeding schedule within each group

	Controls n= 50 (%)	Cases n= 56 (%)
Fed on demand	30 (60%)	44 (80%)
Generally set times	20 (40%)	11 (20%)
Chi-square = 5.035, df= 1, p= 0.025		

Mothers were also asked how often they gave their infants milk feeds during a 24 hour period. Figure 4.3 shows a summary of the responses for cases and controls. There was missing data for six controls and eight cases. The majority of infants receive between five and seven milk feeds per day.

A t-test was used to examine the significance of the mean difference between the two groups. The results can be found in table 4.2c. The mean number of feeds per day for was 6.49 for controls and 7.45 for cases. The difference between the two means, 0.96 was not great enough to identify a statistically significant difference between the two groups ($t= -1.182$, $df= 131$, $p= .24$).

Figure 4.3 Frequency of feeds for cases and controls during a 24 hour period

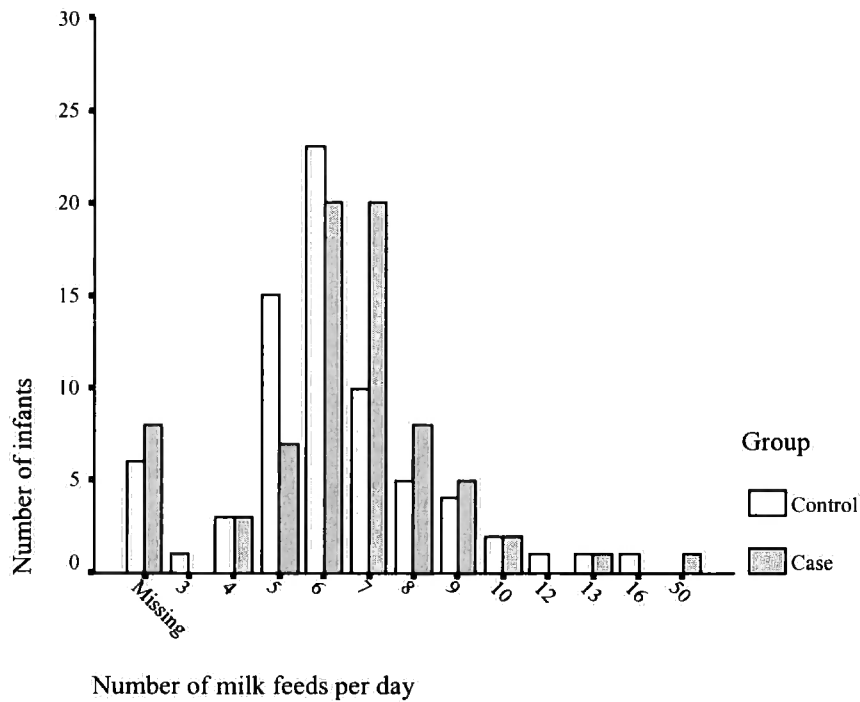


Table 4.2.c T-test results for number of feeds per 24 hours for cases and controls

	n	Mean	S.D.
Controls	66	6.59	2.13
Cases	67	7.45	5.49

T= -1.18, df = 131, p= .24

The next general feeding question was whether infants received any bottled milk, i.e. formula milk. This question was designed to help us understand more about how mothers were feeding their infants at six weeks. The questionnaire had already asked the mother to state the feed type of her infant (see previous analysis on page 150).

The response data for the question regarding the receiving of bottled milk was categorical: 'Not at all', 'Occasionally' or 'Frequently'. Figure 4.4 shows the frequency data for cases and controls. There was missing data for some infants. The figure shows that the most common response was that both case and control infants frequently receive bottled milk. There does not seem to be any obvious difference between the two groups on this question. However, a chi-square analysis was carried out on the categorical data and the results can be found in table 4.2.d. The results show that there was no statistically significant difference in the responses of the mothers.

Figure 4.4 Frequency of responses for whether the infant received bottled milk

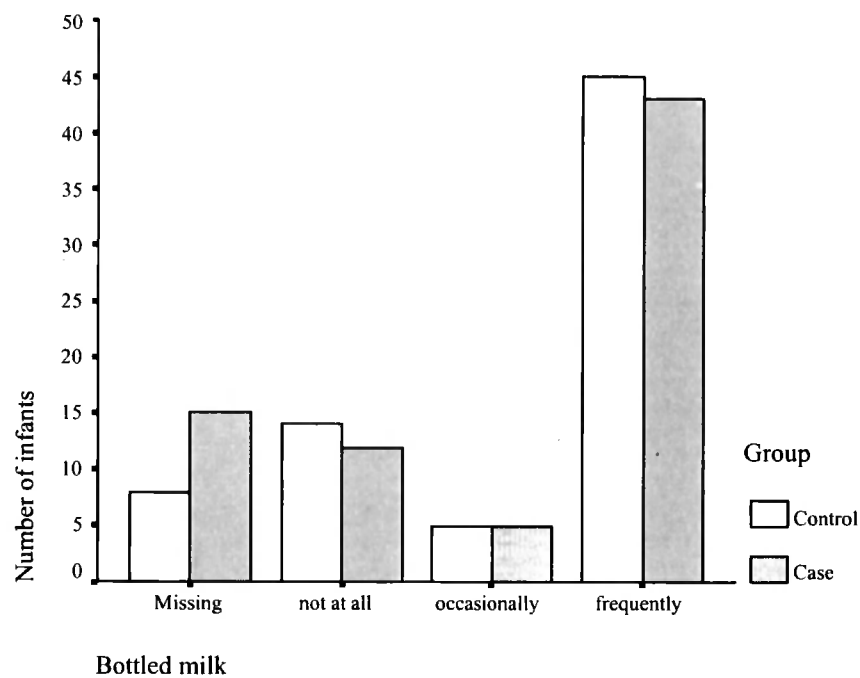


Table 4.2.d Chi-square analysis for bottled milk

	Controls (n=64)	Cases (n=60)
Not at all	14 (21.9%)	12 (20%)
Occasionally	5 (7.8%)	5 (8.3%)
Frequently	45 (70.3%)	43 (71.7%)
Chi-square = 0.7, df=2, p=.97		

4.3 Volume and duration

The series of questions were designed to collect information about the volume and duration of feeds in cases and controls. Firstly, mothers were asked to estimate the volume intake per feed and the duration of each feed. The responses were categorical, that is, the categories were already constructed for mothers to respond within. If the infants received bottled milk, the mother was asked to estimate how many ounces the infant received. If the infant was breast fed, the mother could not provide this information, so the graphs represent only bottle fed infants. Figure 4.5 show the distribution of answers made by mothers of cases and controls for the volume consumed per feed. No mothers of cases and controls estimated their infants intake as less than 2 oz. A chi-square test was used to analyse the frequency of responses within each category according to group. Table 4.3.a shows a summary of the chi-square analysis. There was no statistically significant difference between the two groups.

Similarly mothers were asked to estimate how long their infants' feeds usually were. The response data was categorical and options they had available and the frequency of their responses are shown in figure 4.6. The figure shows that neither mothers of cases or controls had feeds of less than five minutes. A chi-square analysis was conducted on the categorical data and the results can be found in table 4.3.b. The analysis showed there was no statistically significant difference between cases and controls. This means that mothers do not report any differences in the intake and duration of the feeds. This is a significant find since there was a possibility that case infants would feed differently and this in turn would contribute to their weight.

Figure 4.5 **Frequency of responses for volume intake in bottle feeders**

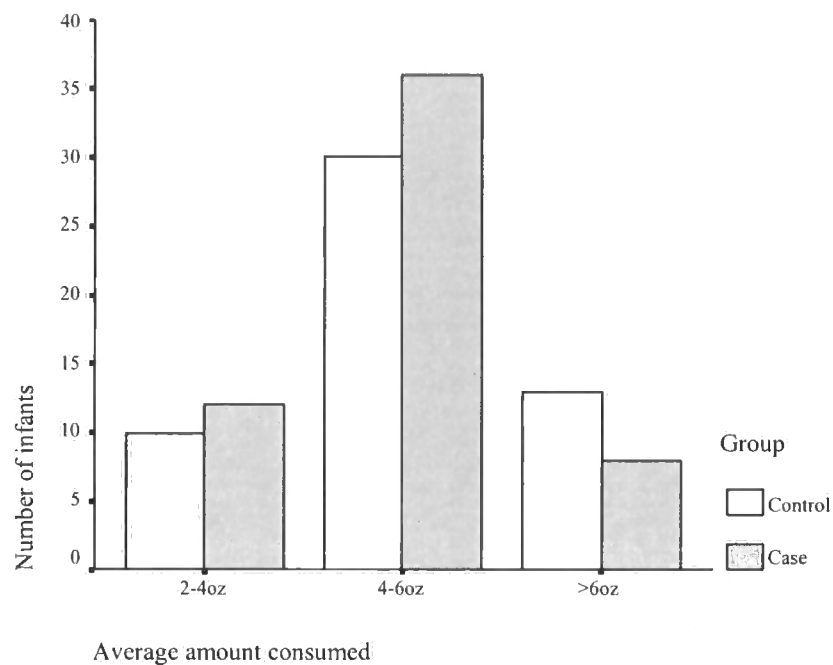


Table 4.3.a **Frequency of responses for estimated volume intake**

	Controls (n=53)	Cases (n=56)
2-4 oz	10 (18.9%)	12 (21.4%)
4-6 oz	30 (55.6%)	36 (64.3%)
6 or more	13 (24.5%)	8 (14.3%)
Chi-square = 1.84, df=2, p=.40		

Figure 4.6 Frequency of responses for estimated duration of feeds

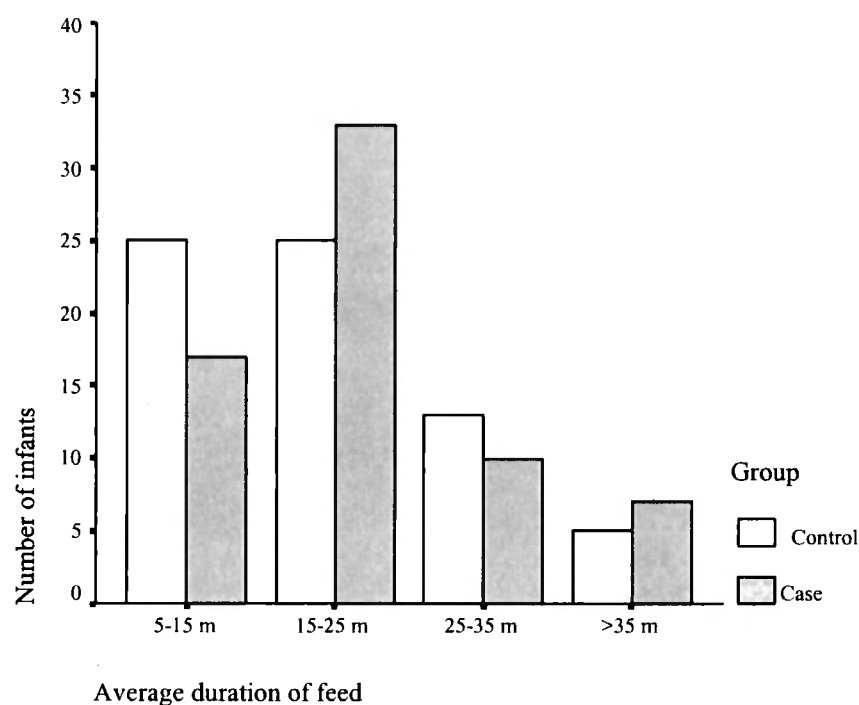


Table 4.3b Estimated duration of feeds

	Controls (n=68)	Cases (n=67)
<5 minutes	0	0
5-15 minutes	25 (36.8%)	17 (25.4%)
15-25 minutes	25 (36.8%)	33 (49.3%)
25-35 minutes	13 (19.1%)	10 (14.9%)
> 35 minutes	5 (7.4%)	7 (10.4%)
Chi-square = 3.35, df= 3, p= .34		

4.4 Appetite

There were a series of questions designed to collect data about the infants appetite. For each question the mother could respond by choosing the appropriate answer to suit her infants' behaviour. The answers to these questions were coded in a way that would enable the experimenter to calculate a descriptive score for the frequency of problems reported. Table 4.4a shows a summary of the scoring criteria for each of the responses for the questions relevant to appetite. The responses for question 18 were scored as 0 for 'Very good/good/average', 1 for 'Poor' and 2 for 'Very poor'. The responses for question 19 were scored as 0 for 'Yes', 1 for 'Not always' and 2 for 'No'. Questions 24b, 24d and 24e contained the same possible responses. Regarding question 24e, if a mother reported that occasionally her infant was not satisfied it could be inferred that the infant did not have a poor appetite, but an appetite of a hungry infant. However, if an infant is occasionally not satisfied it does suggest that there is some evidence of an appetite that cannot be satisfied. Question 24a (Does baby have to be woken for feeds?) was omitted from the analysis because of the problems with coding the responses. For example the response categories were 'Not at all', 'Occasionally' and 'Frequently'. The problem is that if a baby has to be frequently woken for feeds, it could be concluded that at least the infant is offered food by the caregiver and this does not seem unusual since most babies sleep prior to feeds. If a baby never has to be woken for feeds, it could be interpreted that the infant sleeps for long periods and is fed on waking, this too is not unusual. Therefore the problems with coding this responses to this question to illustrate that it was difficult to determine what was normal and abnormal sleeping behaviour. For this reason the question was omitted from the analysis. Therefore, this question was given a score of 1. The answer for each question

was therefore given a score. If a mother reported no problems for a particular question, the response was given a score of 0. If a mother reported that there was occasionally a problem the response was given a score of 1. Finally if the problem was reported as 'frequent', the response was given a score of 2.

If an infant scored a total of 0 for all of these questions related to appetite, this meant that the mother reported no problems with their appetite. If an infant scored a total of 1 or 2 for the questions related to their appetite, this meant that the mother reported the occasional problem with their appetite. Finally if the infant scored a total of 3 or more, this was considered a high number of occurring problems. Figure 4.7 shows that there is a higher incidence of problems reported by mothers of cases than that of controls. Mothers of cases were more likely to report three or more problems.

Statistical analysis was conducted to investigate group differences. A Mann-Whitney U test was used to analyse the mean appetite scores of cases and controls. Table 4.4.b shows a summary of the Mann-Whitney U test. There was a statistically significant difference between the cases and controls. This means that mothers of case were more likely to describe their infants appetite as poorer than control infants.

Table 4.4a**Questions related to appetite and the scoring
procedure for answers.**

Question	Response	Score
Q18 How is your baby's appetite?	Very Good	0
	Good	0
	Average	0
	Poor	1
	Very poor	2
Q19 Is baby feeding enough?	Yes	0
	Not always	1
	No	2
Q24b Does baby sleep through feeds?	Not at all	0
	Occasionally	1
	Frequently	2
Q24d Is baby a slow feeder?	Not at all	0
	Occasionally	1
	Frequently	2
Q24e Is baby not satisfied?	Not at all	0
	Occasionally	1
	Frequently	2

Figure 4.7 **Frequency of reported problems on appetite questions**

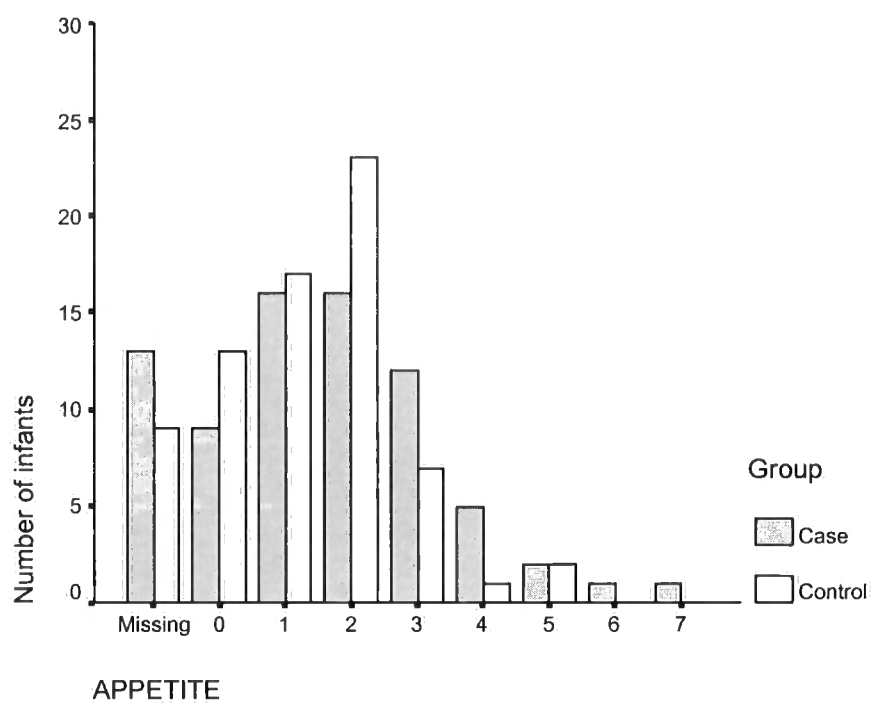


Table 4.4b **Mann-Whitney test results for appetite score
for cases and controls**

	n	Mean rank	Sum of mean Rank
Control	62	55.60	3447.00
Case	62	69.40	4303.00
Mann-Whitney U= 1494, z= -2.179, p= .02			

4.5 The feeding situation

There were a series of questions designed to collect information about the feeding situation. This is an important area of investigation because mothers of cases may experience more difficulty feeding their infants and these poor interactions with infants during feeding times may explain why some infants fail to thrive. The responses to these questions were scored and summarised in a similar way as for the appetite responses. Table 4.5a shows a summary of the questions and the weighting given to each of the responses.

Figure 4.8 shows a distribution of the feeding situation scores across the group. The number of reported problems were analysed across the two groups. A Mann-Whitney U test was used to analyse the mean differences between the two groups. Table 4.5.b shows a summary of the results for the Mann-Whitney U test. There was no statistically significant difference between the two groups. This means that mothers of cases reported the feeding situation no differently to that of controls. This is interesting as it suggests that cases are no more difficult to feed than control infants.

Table 4.5a **Questions related to the feeding situation and the scoring procedure for answers.**

Question	Response	Score
Q20 At present, are feeding times for you usually	Very relaxed	0
	Relaxed	0
	Alright	0
	Stressful	1
	Very stressful	2
Q21 At present, are feeding times for your baby?	Very relaxed	0
	Relaxed	0
	Alright	0
	Stressful	1
	Very stressful	2
Q22 At present, is your baby easy to feed?	Very easy	0
	Easy	0
	Alright	0
	Difficult	1
	Very difficult	2
Q24c At present, do any of the following describe your baby?		
Cries during feeds?	Not at all	0
	Occasionally	1
	Frequently	2

Figure 4.8 Number of problems reported on the feeding situation

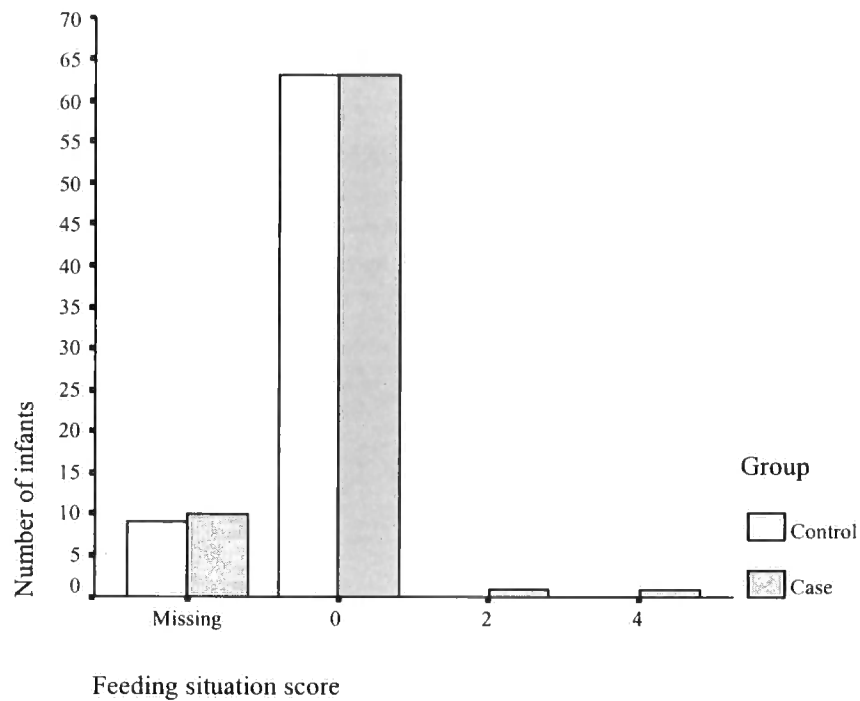


Table 4.5b **Mann-Whitney U test results for the feeding situation score for cases and controls**

	n	Mean rank	Sum of mean Rank
Control	63	63.50	4000.50
Case	65	65.47	4255.50

Mann-Whitney U= 1984.5, z= -1.40, p= .16

4.6 Oral motor problems

A series of questions were designed to collect information about the frequency of oral motor problems in infants. It is important to record this since cases and controls may differ in the frequency of oral motor problems. Table 4.6a shows a summary of the questions relevant to oral motor problems and the weightings the responses were given for analysis.

Figure 4.9 shows a distribution of scores for cases and controls. The distribution shows that the scores are not normally distributed, so a Mann-Whitney U test was used to compare the groups. Table 4.6b shows a summary of Mann-Whitney U results. There was no statistically significant differences between the two groups. There are issues regarding effect size and power for this analysis, and these will be tackled in a section at the end of this chapter.

Table 4.6a**Questions related to oral motor problems
and the scoring procedure for answers.**

Question	Response	Score
Q17 At present, how well does your baby suck?	Strong	0
	Average	0
	Weak	1
Q23a Does your baby have any trouble with the following:		
Sucking?	Not at all	0
	Occasionally	1
	Frequently	2
Q23b Swallowing?	Not at all	0
	Occasionally	1
	Frequently	2
Q23c Choking?	Not at all	0
	Occasionally	1
	Frequently	2

Figure 4.9 **Number of problems reported for oral motor problems**

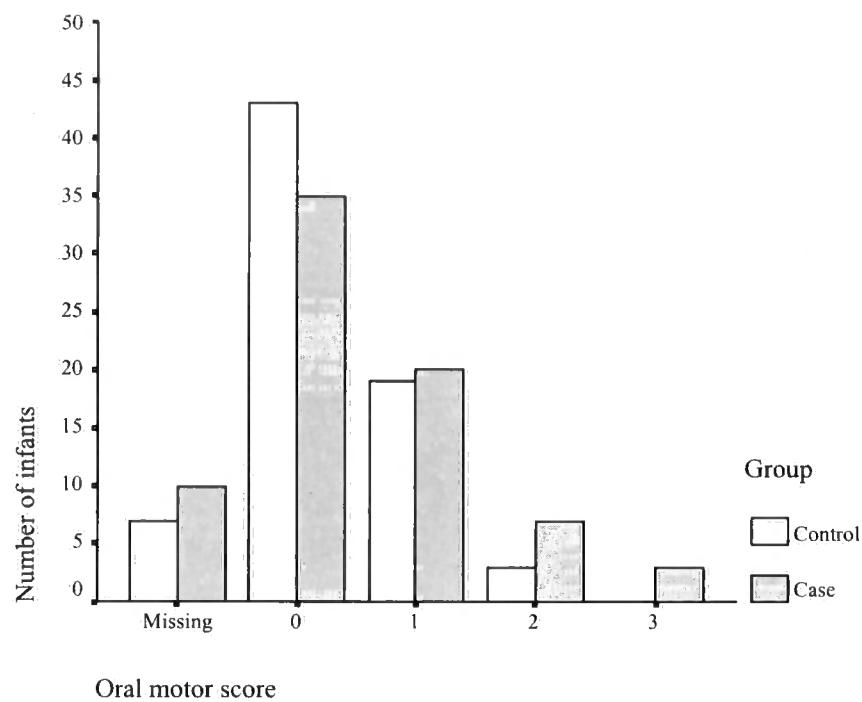


Figure 4.6b **Mann-Whitney U test results for oral motor problems.**

	n	Mean rank	Sum of mean Rank
Control	65	60.43	3928
Case	65	70.57	4587

Mann-Whitney U= 1783, z= -1.76, p= .08

4.7 Regulation of intake

Regulation of intake is important in failure to thrive research. If an infant cannot keep their food down and are prone to possetting or vomiting, their absorption of food is reduced. Possetting and vomiting may be an indication that there is some kind of digestive problem. This in turn will affect growth. Within the six week feeding questionnaire, two questions were devoted to possetting and vomiting. Figure 4.10 shows the distribution of regulation of intake scores for cases and controls. The scores are not normally distributed with a score of 1 being most common.

Figure 4.10 Number of reported problems for regulation of intake

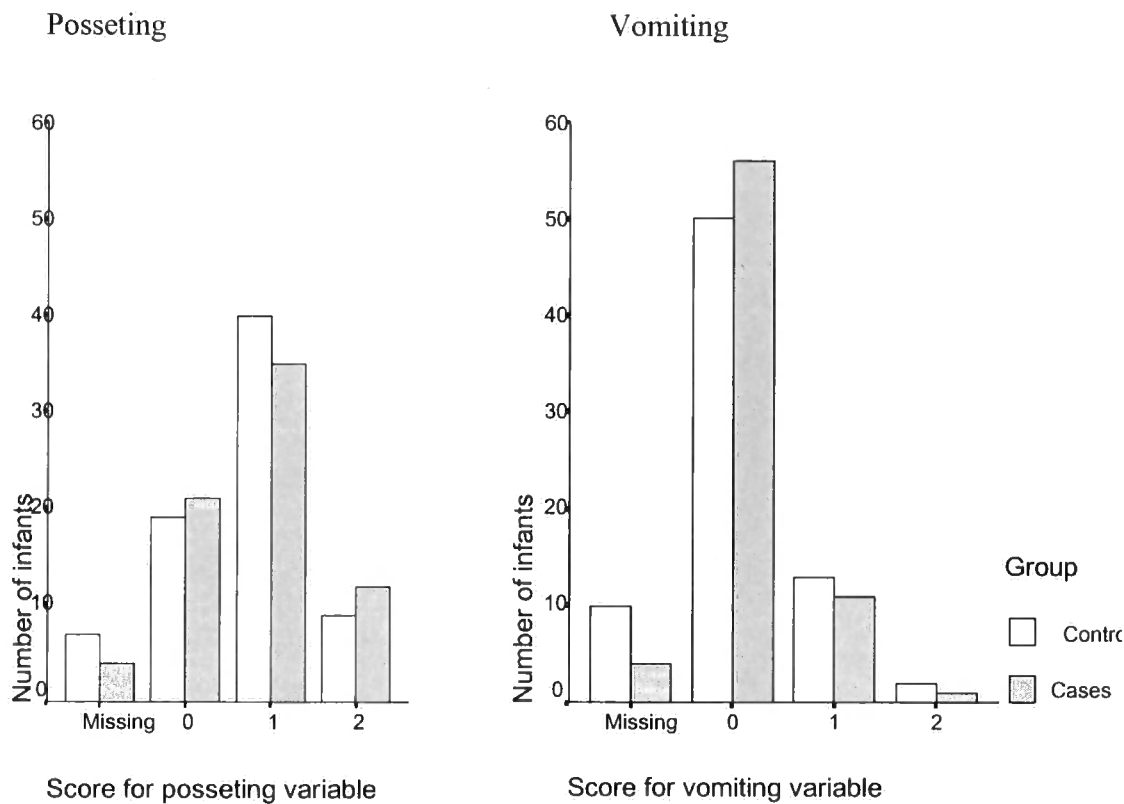


Table 4.7a Analysis of questions relating to the regulation of intake

Possetting	Not at all	Occasionally	Frequently
Control (n=68)	19 (27.9%)	40 (58.8%)	9 (13.2%)
Case (n=68)	21 (30.9%)	35 (51.5%)	12 (17.6%)
Chi-square = .862, df= 2, p= .650			
Vomiting			
Control (n=65)	50 (76.9%)	13 (20%)	2 (3.1%)
Case (n=68)	56 (84.4%)	11 (16.2%)	1 (1.5%)
Chi-square = ..772, df= 2, p= .68			

Table 4.7a shows that there were no statistically significant differences between the groups. This means that mothers of cases do not report a higher incidence of possetting and/or vomiting than mothers of controls.

4.8 Body image

The final area of analysis within the questionnaire data was concerned with body image. This is important because mothers of cases may report their infants as appearing physically lighter/thinner to them than controls would. If a mother reports her infant as thin it would mean that she is aware that her infant looks dissimilar to other infants. On the other hand if a case mother reports no body image no differently than controls, this means that case infants do not look any different to control infants to their mother.

In the six week questionnaire mothers were asked to rate their infant's body fat. Figure 4.11 shows a frequency of the responses made. To analyse the data, the categories of 'Very thin' and 'Thin' were collapsed. The 'Fat' category was excluded since there were no responses in this category. Analysis of the responses (Table 4.8a) showed that there was no statistically significant difference between cases and controls. This means that mothers of cases rate their infants' body image no differently to that of controls. This would suggest that at six weeks of age case infants do not look any different to control infants to their mothers.

Figure 4.11 Frequency data for body image

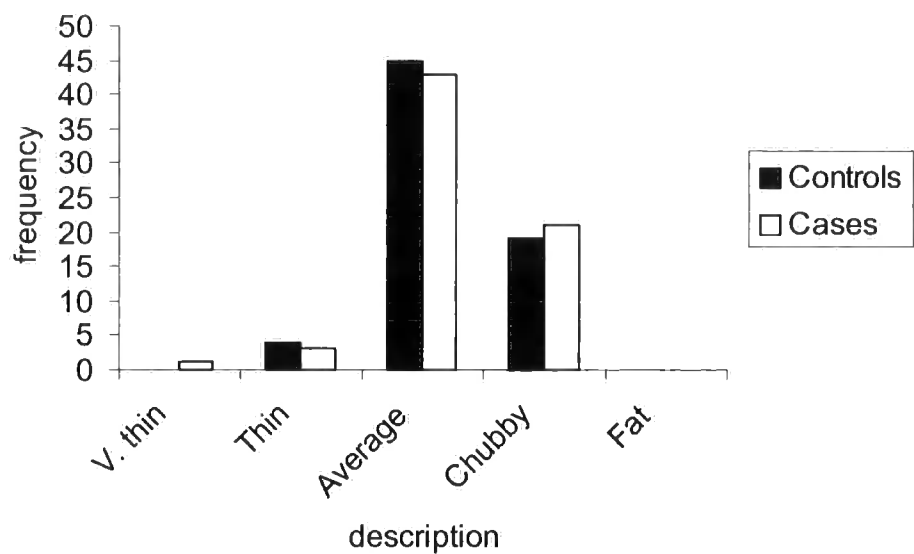


Table 4.8a Mothers rating of their infants body fat

	Controls (%)	Cases (%)
Very thin/ thin	5.9	5.9
Average	66.2	63.2
Chubby	27.9	30.9
Chi-square = .15, df=2, p=0.93		

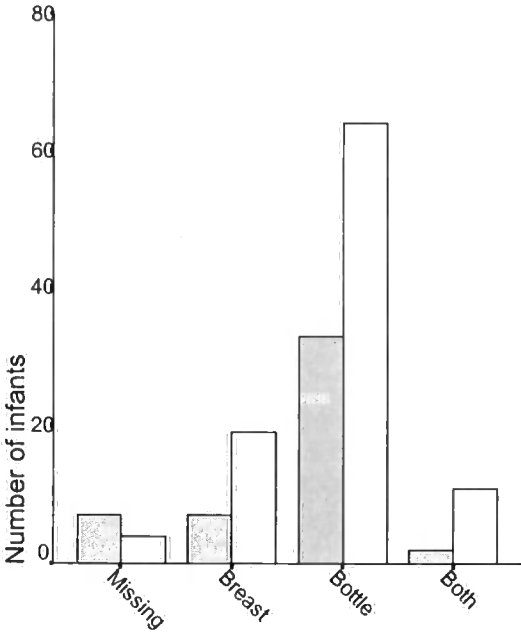
4.9 Analysis of infants followed up and infants not followed up

This section repeats the analyses of the previous sections, except that here between infants followed up ($n=49$) and infants not followed up ($n=98$) is made. The previous chapter described in detail the data collected during the follow up study, when infants were aged between eight and twelve weeks.

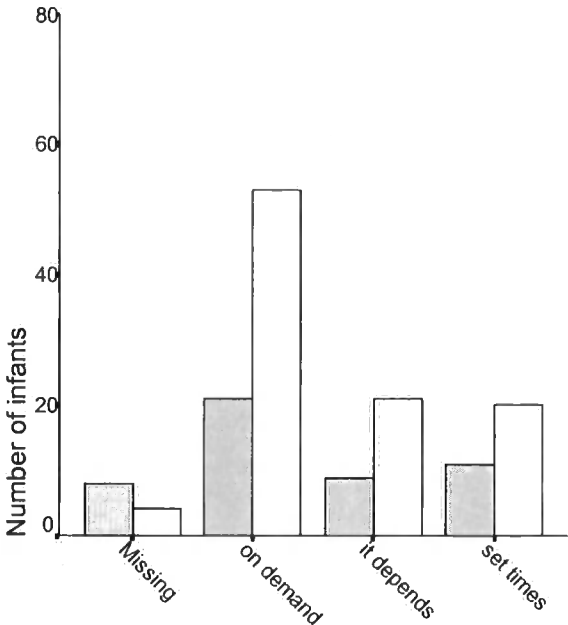
Figure 4.12 shows the distribution plots for the general feeding questions and table 4.9a shows a summary of the analyses conducted on the general feeding questions. The table shows that the only statistically significant difference between the two groups is the number of feeds per 24 hours. Infants not followed up were more likely to receive more feeds than infants not followed up.

Figure 4.13 shows the distribution of responses for cases and controls concerning volume and duration. The results of the analyses can be found in table 4.9b. There were no statistically significant differences between the two groups.

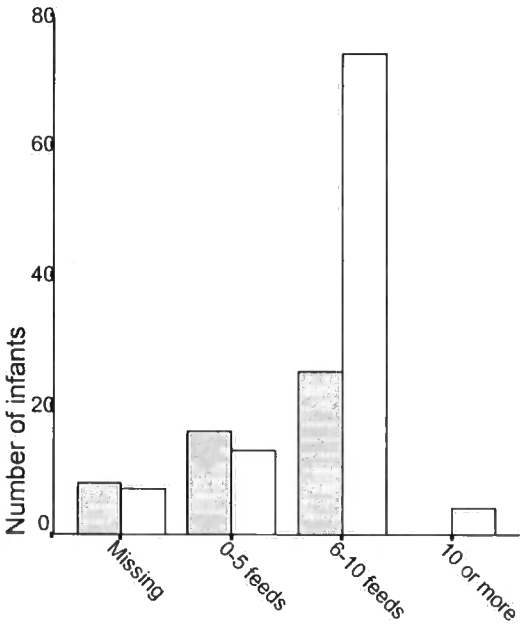
Figure 4.12 Distribution of answers for general feeding questions



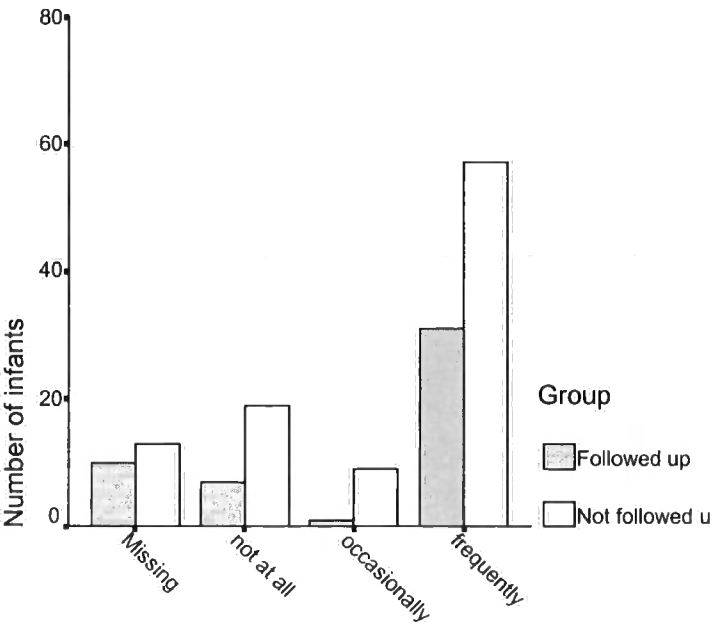
Feed type at six weeks



Fed on demand or schedule?



Number of milk feeds per day



Bottled milk

Table 4.9a

Summary of analyses of general feeding
questions for infants not followed up and followed up

	<i>Not followed up (%)</i>	<i>Followed up (%)</i>
<i>Feed type</i>		
Breast	19 (20.2%)	7 (16.7%)
Bottle	64 (68.1%)	33 (78.6%)
Breast & bottle	11 (11.7%)	2 (4.8%)
Chi-square = 2.1, df = 2, p= 0.35		
<i>Feeding schedule</i>		
Fed on demand	53 (72.6%)	21 (65.6%)
Generally set times	20 (27.4%)	11 (34.4%)
Chi-square = 0.52, df = 1, p= 0.471		
<i>Number of milk feeds per day</i>		
Mean	7.45	6.04
S.D	4.90	1.30
T= 1.81, df=130, p=.15		
<i>Bottled milk</i>		
Not at all	19 (22.4%)	7 (17.9%)
Occasionally	9 (10.6%)	1 (2.6%)
Frequently	57 (67.1%)	31 (79.5%)
Chi-square = 2.96, df=2, p=.23		

Figure 4.13 Distribution of volume and duration of feeds in infants followed up and infants not followed up.

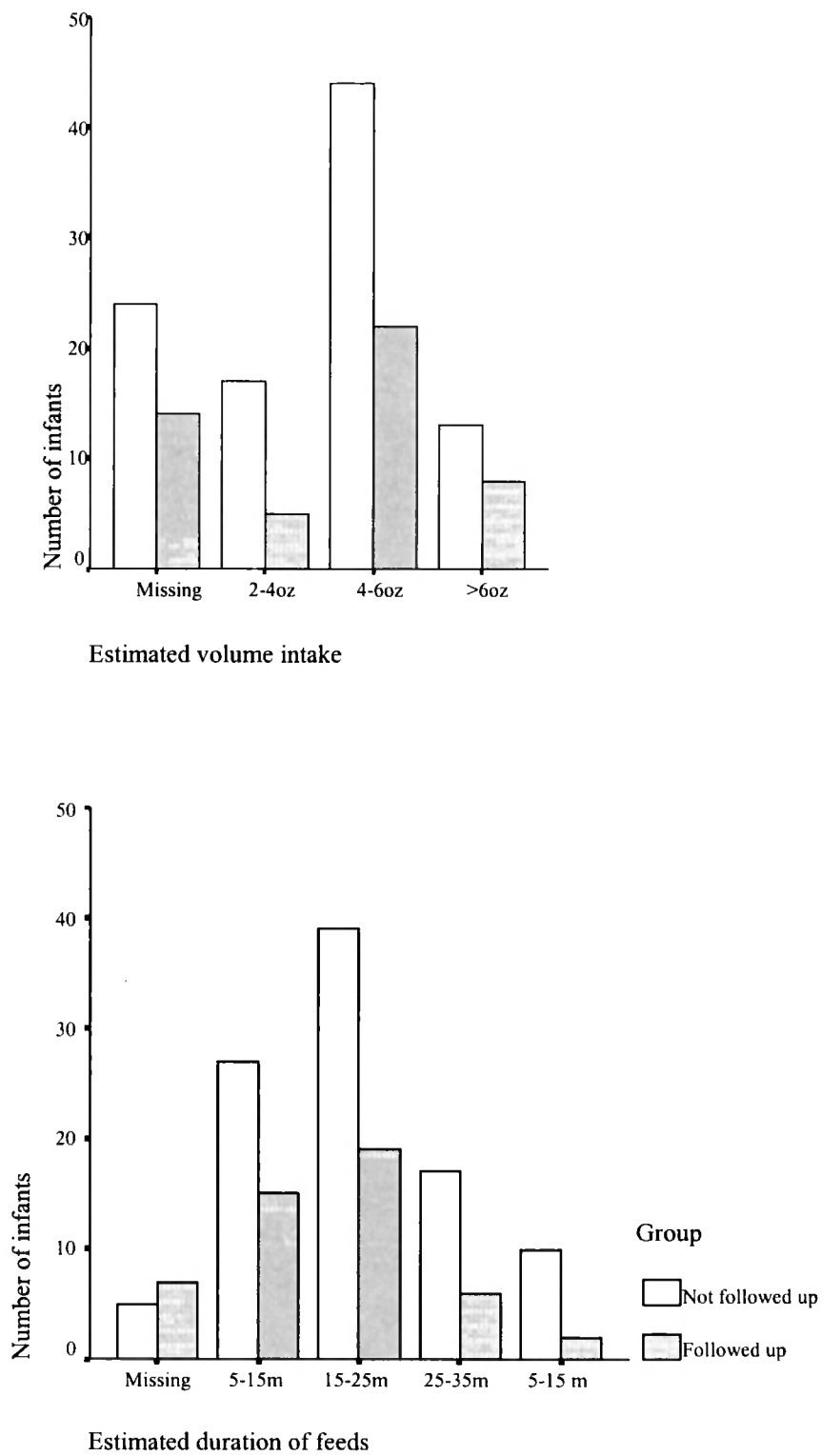


Table 4.9b

Summary of analyses for estimated volume intake and duration of feeds.

	Not followed up (%)	Followed up (%)
Estimated volume intake per feed		
2-4 oz	17 (23.0%)	5 (14.3%)
4-6 oz	44 (59.5%)	22 (62.9%)
6 or more oz	13 (17.6%)	8 (22.9%)
Chi-square = 1.28, df=2, p=.53		
Estimated duration of feeds		
<5 minutes	0	0
5-15 minutes	27 (29.0%)	15 (35.7%)
15-25 minutes	39 (41.9%)	19 (45.2%)
25-35 minutes	17 (18.3%)	6 (14.3%)
> 35 minutes	10 (10.8%)	2 (4.8%)
Chi-square = 1.93, df= 3, p= .59		

Figure 4.14 shows the distribution of scores for appetite, feeding situation, oral motor and possetting and vomiting. Table 4.9c shows a summary of results for each of these, plus body image. The table shows that there were no statistically significant differences on any of the variables. For the results regarding possetting, effect size and power were examined. The details of this further analyses are detailed in the next section.

Figure 4.14 Comparison of infants followed up and not followed up.

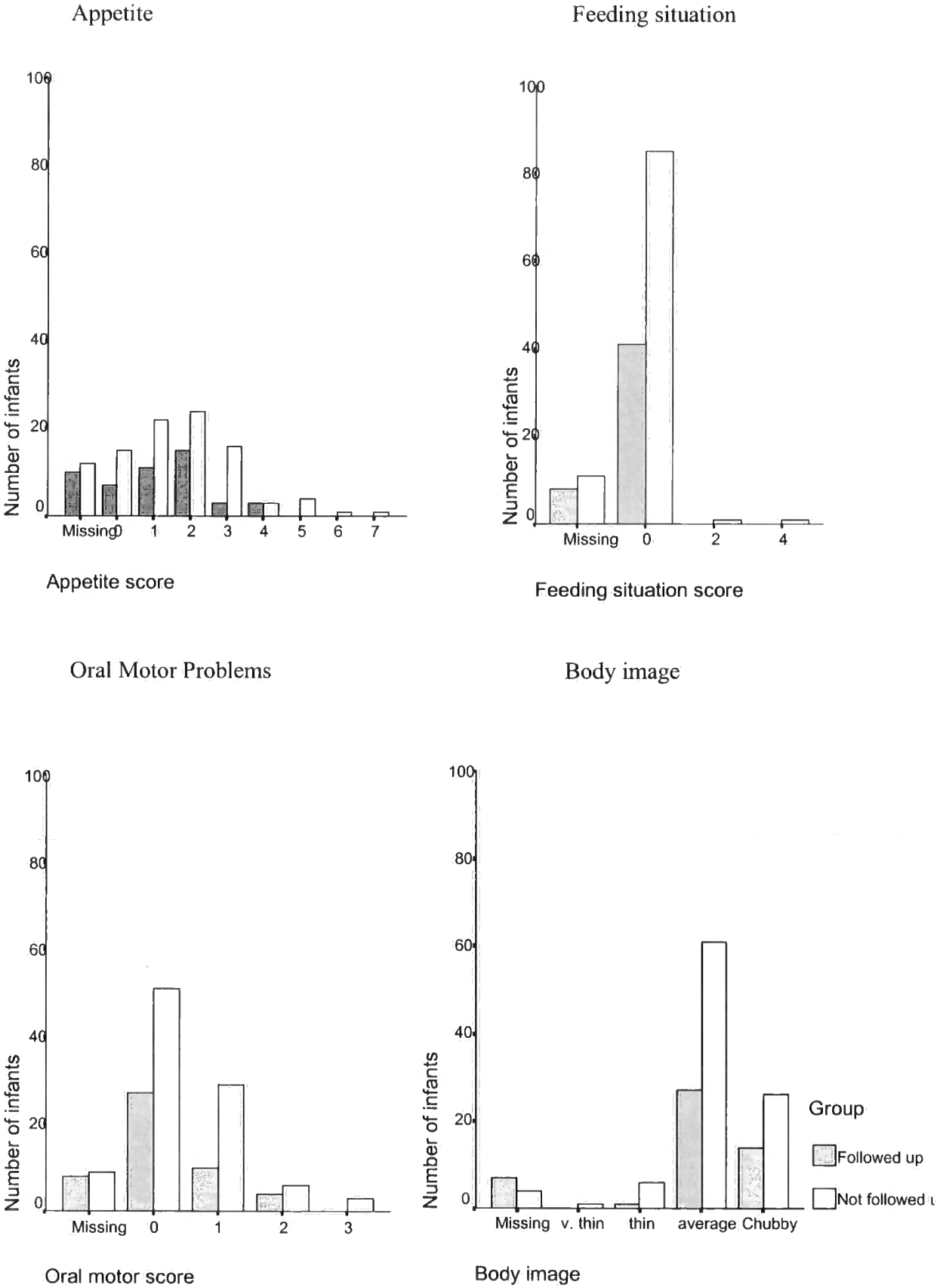


Figure 4.14 Comparison of infants followed up and not followed up continued.

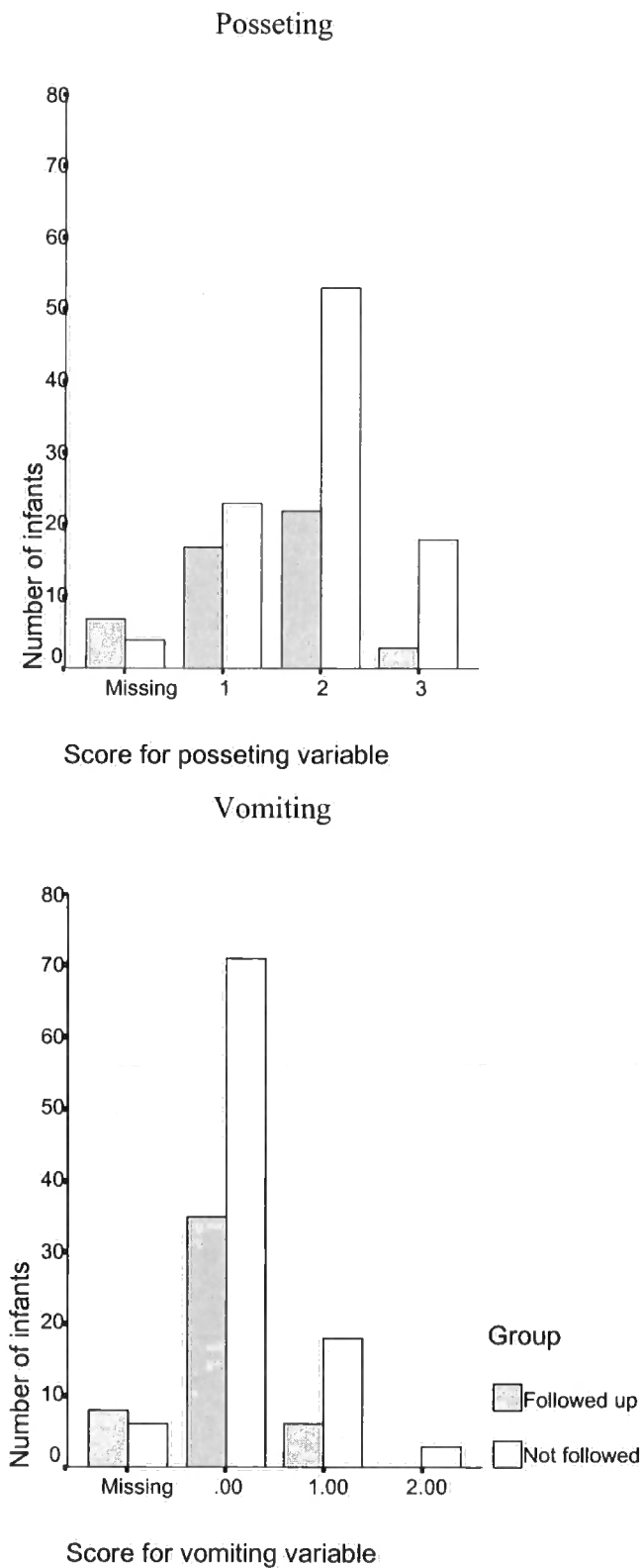


Table 4.9c

**Summary of analyses for infants followed up
and infants not followed up**

	<i>Not followed up (%)</i>	<i>Followed up (%)</i>
<i>Appetite</i>		
N	87 (88%)	39 (79%)
Mean rank	66.51	56.78
Sum of ranks	5786.50	2214.50
Mann-Whitney U = 1434.5, z=-1.434 , df=2, p= 0.15		
<i>Feeding situation</i>		
N	87 (88%)	41 (83%)
Mean rank	64.97	63.50
Sum of ranks	5652.50	2603.50
Mann-Whitney U = 1742.5, z= -.975 , df=2, p= 0.33		
<i>Oral motor</i>		
N	89 (90%)	41 (83%)
Mean rank	67.17	61.87
Sum of ranks	5978.50	2536.50
Mann-Whitney U = 1675.5, z= -.858 , df=2, p= 0.39		
<i>Body Image</i>		
Very thin/ thin	7 (7.4%)	1 (2.4%)
Average	61 (64.9%)	27 (64.3%)
Chubby/ very fat	26 (27.7%)	14 (33.3%)
Chi-square = 1.67, df=3, p= 0.64		

Table 4.9c

**Summary of analyses for infants followed up
and infants not followed up continued**

	<i>Not followed up (%)</i>	<i>Followed up (%)</i>
<i>Regulation of intake</i>		
Possetting		
Not at all	23 (24.5%)	17 (40.5%)
Occasionally	53 (56.4%)	22 (52.4%)
Frequently	18 (19.1%)	3 (7.1%)
Chi-square = 5.32, df= 2, p= .07		
<i>Vomiting</i>		
Not at all	71 (71.2%)	35 (85.4%)
Occasionally	18 (19.6%)	6 (14.6%)
Frequently	3 (3.3%)	0
Chi-square = 1.958, df= 2, p= .376		

4.10 Effect size and power

Power is an important issue when conducting statistical analyses. The power of a statistical test can be reduced by small significance criteria, sample size and effect size. Power refers to the probability of correctly rejecting a false null hypothesis. As alpha increases the power increases. As sample size increases, the variance of the distributions decreases reducing the overlap between them resulting in an increase in power. As the difference between the means of the sampling distributions increase the overlap between them increases and power increases.

A number of tests within this chapter have shown statistically non significant results. Two tests suggested that there might be a trend in the data. The first test examined cases/controls on a number of oral motor problems. A Mann-Whitney test gave a p value of .08. A Chi-square analysis of a sample followed up compared with a sample not followed up on occurrence of possetting gave a p value of .07. To see if there is a difference in the distributions of the data that might be driving the trend an analysis of effect size was conducted on both of these tests. For the Mann-Whitney test the effect size was $r = .2$ and for the Chi-square $w = .2$. Following Cohen (1992) this means that there was a 'small' effect size observed for the Mann-Whitney but there was a 'medium' effect size for the Chi-square. The effect size for the Mann-Whitney was not of practical significance whereas the effect size for the Chi-square suggests that there was a trend towards significance. For .8 power regarding the Mann-Whitney analysis a sample size of 310 would have been required, whereas for the Chi-square analysis a sample size of 48 would have been required. In the case of the Chi-square a larger sample size was used ($n = 136$) and therefore suggesting that the trend observed was of no practical significance (Cohen, 1988).

4.11 Summary

This chapter has analysed the six week questionnaire data. The questionnaire was designed with specific areas of interest related to infant feeding. A statistically significant difference was found for feeding schedule and appetite. The results showed that cases were more likely to be fed on demand than controls. Mothers of case infants were more likely to

describe their infants appetite as poorer than that of controls. All other group comparisons for general feeding, feeding situation, oral motor problems, regulation of intake and body image, were statistically non significant. Additional analyses of infants followed up at eight to twelve weeks and infants not followed up showed no statistically significant differences.

Chapter 5 :

Analysis of feeding behaviour for the observational study (8-12 weeks)

Chapter 5

Analyses of feeding behaviour for the observational study

(8-12 weeks)

5.1 Introduction

The previous chapter examined the six week feeding questionnaire data. This chapter examines the data objectively recorded by observational methods when the infants were eight to twelve weeks old.

The aim of this part of the study was to record and analyse the feeding behaviour of case and control infants and compare these two groups. There were 19 cases and 30 controls observed between the ages of eight to twelve weeks. Chapter two described the procedure for this study in detail, and refer to sections 2.4 for details about the procedure for collecting the data. The procedure for analysing the sucking data can be found in section 2.5.4 and the procedure for analysing the formula milk samples can be found in section 2.5.5.

This chapter is divided into sections that analyse the data collected during the follow up study. Section 5.2 describes the infants' sucking behaviour, the measurement and analysis, section 5.3 examines the other measurements at follow up, weight, feed type, duration of feeds and intake. Section 5.4 examines the reconstitution of formula milk and 5.5 examines the feeding diaries provided by mothers 48 hours prior to the experimenter's visit at follow up. The chapter concludes with a summary of the main findings.

5.2 Recording sucking behaviour

A video recording was taken of the infant feeding in the natural environment. The video was later played back and a specialised program was then used to convert the observational behaviours into a computer file. The behaviours were recorded manually into the computer file by the experimenter who had to press designated keys for particular behaviours. These keys were designated as follows. The mother can give (a) the infant the breast or bottle and take the infant off (y). The infant can suck (z/v); reject (j) or release (k) the breast or bottle. If at any point the infant's sucking becomes obscured from view, the experimenter would code (m) and when it became visible again they would use (n). The computer program recorded time from start to finish, with a recorded time for each behaviour. From the output file it was possible to examine the intervals from one suck to the next. Each output file contained the coded information for one feed, since two consecutive feeds were recorded for each infant observed in this study, two output files existed for each infant. To examine the intervals between the observed behaviours, every output file was converted into separate SPSS files, with one SPSS file containing the converted information for a single feed. Within each SPSS file the time of the first observable suck (i.e. z or v) was set at 00.00. For every behaviour that followed the first observable suck, an accumulative time was recorded in s. The first visible suck signifies the start of the feeding episode and the last visible suck signifies the end of the feeding episode.

To assess the time between behaviours, another variable was created within the same SPSS file, that was lagged by one event, allowing the time difference between codes to be calculated. A file of the suck to suck intervals (in s) was written out of SPSS for analysis in Splus. The changes that take place over the course of a normal feed can be

explored visually by graphing the intervals between sucks by the duration of the feed. Figure 5.1 and 5.2 show this information for one bottle fed control and one bottle fed case from this study. The duration of the feed is longer for the bottle fed infant than the breast fed infant. Also there are longer suck intervals are more frequent in the bottle fed infant than the breast fed infant.

Figure 5.1 **Graph showing the intervals between sucks during the course of one feed in a bottle fed control infant.**

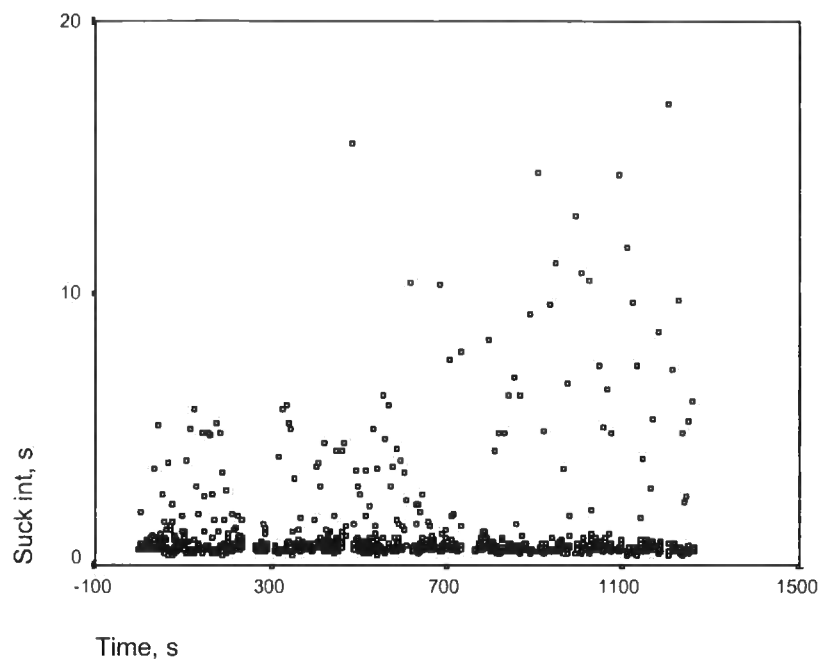
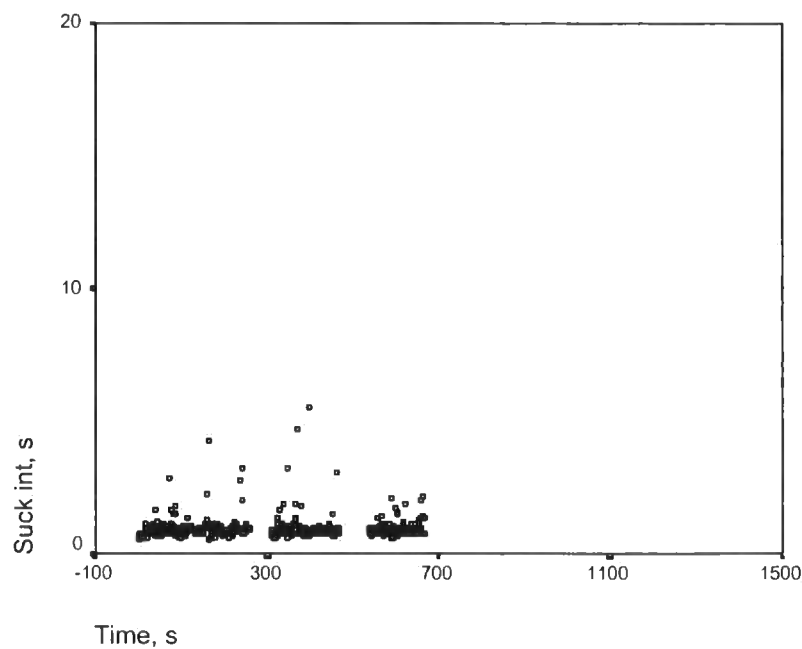


Figure 5.2 **Graph showing the intervals between sucks during the course of one feed in a bottle fed case infant.**



When breast and bottle fed infants feed they suck in bursts with pauses between the bursts. Diagrams of burst-pause behaviour are useful tools to examine a feed visually, however if we wanted to summarise a typical feed using a set of criteria on which to compare a number of infants the task becomes rather complex. Supposing we wanted to examine the mean number of sucks per burst, the mean suck duration and mean pause duration. Typically a suck duration is < 1 s, but pause durations can vary in their length and can overlap the suck durations (Bowen-Jones et al, 1982). We need to distinguish between intervals between sucks and actual pauses. This can be partially achieved using a cut off point that discriminates between an inter suck interval and a pause. Some studies use a cut off point of 2s, with the assumption that ≤ 2 s were suck durations and intervals of > 2 s were pauses (Pollitt et al, 1978b).

For the purposes of the research described here, a mixture model (Chetwynd et al, 1998) was used in order to summarise the sucking behaviour of the infants once a video recording of the feed had been taken. This method was outlined in detail in chapter 2, however it is summarised here to clarify the analytic procedure for studying infant sucking.

The mixture model summarises two distributions simultaneously. The first summarises the suck durations as a normal distribution, with a mean μ and standard deviation σ . The second summarises the pauses as an exponential distribution with mean $\zeta [= \lambda^{-1}]$. The number of sucks within a burst is geometrically distributed with mean $v [= 1/(1-\phi)]$.

These parameters change over the course of a feed, for example the suck durations gradually decrease and the pause durations increase (Drewett & Woolridge, 1979). If t

is the cumulative number of sucks and increases during the course of the feed, then the parameters of μ , σ and λ are assumed to follow a log linear trend in t , for example:

$$\mu(t) = \exp(m_1 + m_2 t)$$

They are always positive. The parameter σ is assumed to follow a logistic-linear trend:

$$\sigma(t) = [\exp(p_1 + p_2 t)] / [1 + \exp(p_1 + p_2 t)]$$

The statistics that were calculated summarise the infants' sucking behaviour. These are presented as characterised sucks at the start of the feed and sucks at the end of the feed. Infants show a higher rate of sucking at the start of the feed with smaller pauses. At the end of the feed when the sucking is less frequent with longer pauses. Two consecutive feeds were recorded for each infant in the study, therefore there were two sets of summary statistics available for each infant.

An example of the sucking parameter estimates for a feed for one infant is summarised in table 5.1a. The estimates were calculated in Splus version 4.0 using a script provided by Chetwynd (Chetwynd et al, 1998). The infant described in Table 5.1a is the same infant shown in Figure 5.1. Figure 5.1 shows the infant's behaviour for feed 1. The sucking parameters for this infant for feed 1 are shown in Table 5.1a. The mean pause length between sucking bursts are shorter at the beginning of the feed (1.06s) and increase towards the end of the feed (5.15s). This can be seen in Figure 5.1 as the suck pause intervals become longer.

Table 5.1a

Summary of feeding behaviour for two consecutive feeds in a randomly selected control infant from the study

	<i>Feed 1</i>	<i>Feed 2</i>
<i>Start of the feed:</i>		
Mean number of sucks per burst	3.72	5.64
Mean suck duration (s)	0.68	0.65
Standard deviation of suck duration	0.13	0.10
Mean pause length (s)	1.06	1.64
<i>End of the feed:</i>		
Mean number of sucks per burst	5.86	5.44
Mean suck duration (s)	0.59	0.60
Standard deviation of suck duration	0.12	0.11
Mean pause length (s)	5.15	1.97

5.2.1 The sucking behaviour of infants from the Millennium Baby Study

Nineteen cases and 30 control infants that were followed up between the ages of eight and twelve weeks of age, and for each infant two consecutive feeds were video recorded and analysed. There are important questions to ask of this data. Firstly, how similar are the two feeds? This was investigated by taking the feeding parameter estimates for the first feed and correlating them with the estimates for the second feed. Table 5.2.1a shows the results of a paired t test and correlation for the first and second feed. For the

eight feeding variables there was only one that was significantly different. Furthermore for five of the eight feeding parameters there is a significant correlation for the first and second feed. Therefore it was felt that the results across the eight variables at feed 1 and feed 2 were similar enough to justify their combination.

In addition an infant's feeding behaviour will differ slightly from one meal to the next, however during a 24 hour period an infant's feeding behaviour does not differ that greatly. Using two feeds to represent the feeding behaviour of infants is sufficient to represent the feeding behaviour of the infant during a twenty four hour period (Black et al, 1983). Therefore, on the basis of this and the apparent similarity between the results at feed 1 and feed 2 using two combined feeds was a useful means of characterising the feeding behaviour of infants in this study. The feeding behaviour for the two feeds can be combined and the mean feeding parameter estimates for the first and second feed can be used in future analyses.

Table 5.2.1a Paired t test and correlation results for Feed 1 and Feed 2

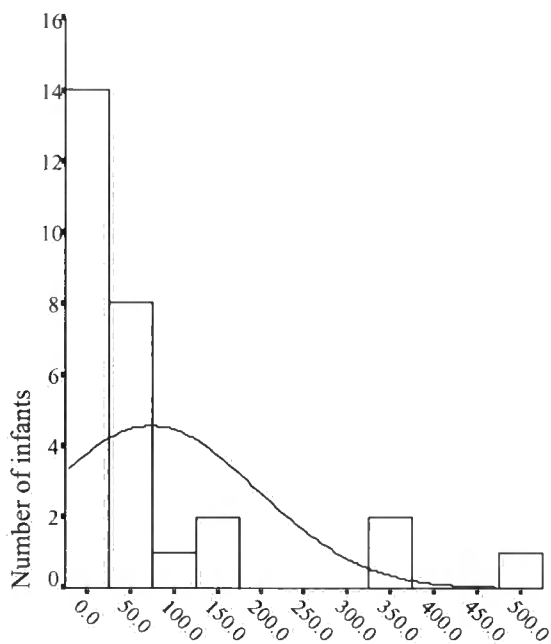
	<i>Feed 1 & Feed 2 (n=49)</i>			
	<i>T value</i>	<i>p</i>	<i>Pearson's r</i>	
Sucks per burst, start	2.087	.043	.214	.154
Sucks per burst, end	-1.042	.303	.239	.109
Suck duration mean, start	-.343	.733	.495	.000
Suck duration mean, end	1.087	.283	.632	.000
Suck duration S.D., start	.025	.980	.398	.006
Suck duration S.D., end	.212	.833	.437	.002
Pause length, start	-.195	.846	.183	.223
Pause length, end	-.992	.327	.321	.030

The next question is whether cases and controls differ in their sucking behaviour. First the distribution for each of the sucking parameter estimates for (the mean for combined feeds) for cases and controls was plotted. Figure 5.3 shows the distribution of the sucking parameters for the mean number of sucks per burst at the start of the feed, and the mean number of sucks per burst for the end of the feed. The distribution of mean number of sucks per burst at the start of the feed compared to the mean number of sucks per burst at the end of the feed appears to be different for cases and controls. Cases appear to have fewer sucks at the start of the feed (28.34) and more sucks per burst at the end of the feed (16.98) when compared to controls (73.76 and 9.22 respectively). Figure 5.4 shows the distribution of the sucking parameters for the mean suck duration at the start of the feed and the mean suck duration for the end of the feed. Figure 5.5 shows the mean suck duration S.D. for the start of the feed and the mean suck duration S.D. for the end of the feed. Finally figure 5.6 shows the mean pause length for the start of the feed and the mean pause length for the end of the feed. Clearly these distributions are not normal so a Mann-Whitney U test was used to compare the means of cases and controls for each of the eight sucking parameter estimates. Table 5.2.1b shows a summary of the U-test analyses for Feed 1 and Feed 2. The table shows that there were no statistically significant differences between the mean sucking parameter estimates for cases and controls. Although the analysis showed no difference between mean number of sucks per burst at the start and end of the feed (figure 5.3), the distribution may be due to more milk being available for controls than cases, hence they become satiated towards the end of the feed and the sucking frequency decreases more markedly for controls than cases.

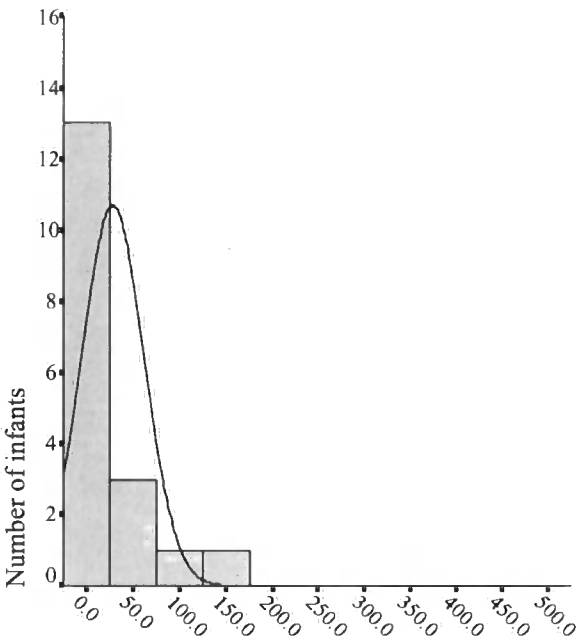
Figure 5.3 Distribution of mean number of sucks per burst for the start and end of the feeds for cases (n=19) and controls (n= 30).

Controls

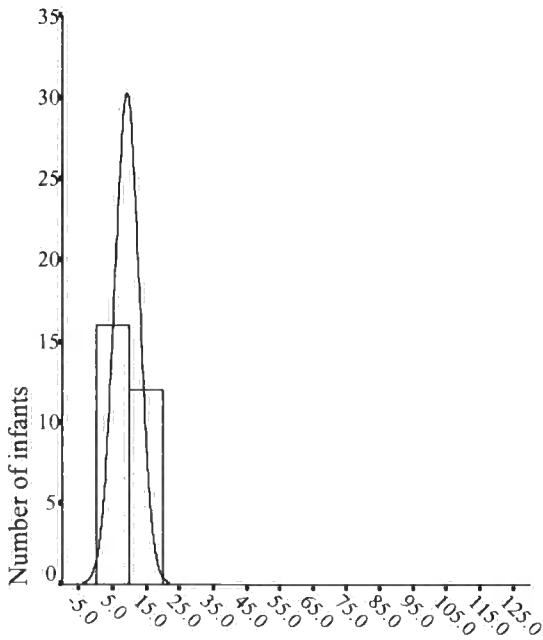
Cases



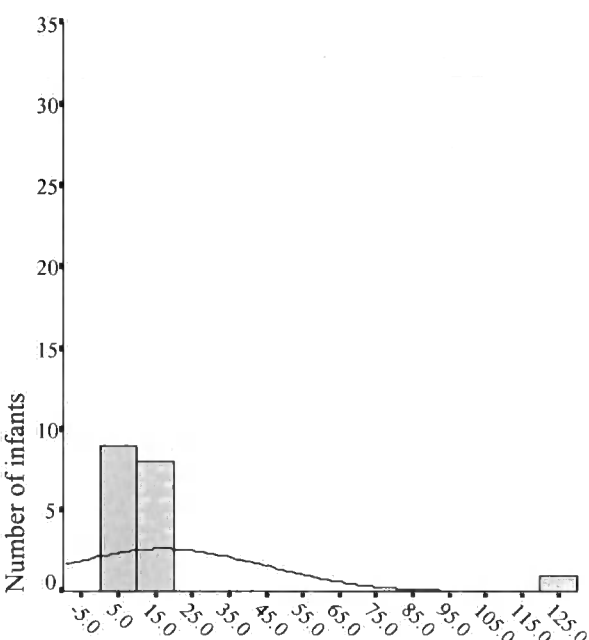
Number of sucks per burst (start)



Number of sucks per burst (start)



Number of sucks per burst (end)



Number of sucks per burst (end)

Figure 5.4 **Distribution of mean suck duration at the start and end of the feeds**
for cases (n=19) and controls (n= 30).

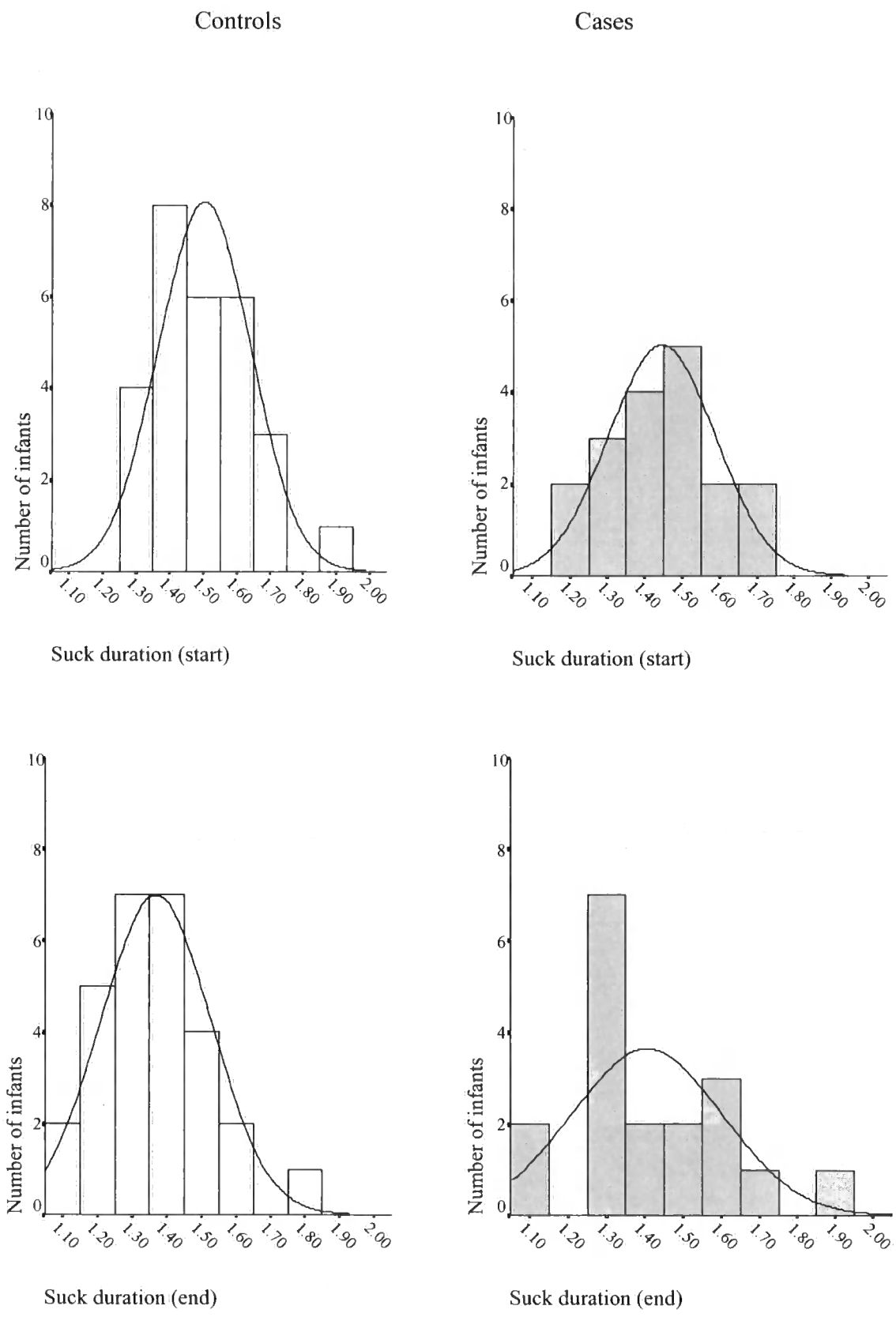


Figure 5.5 Distribution of mean suck duration S.D. for the start and end of the feeds for cases (n=19) and controls (n= 30).

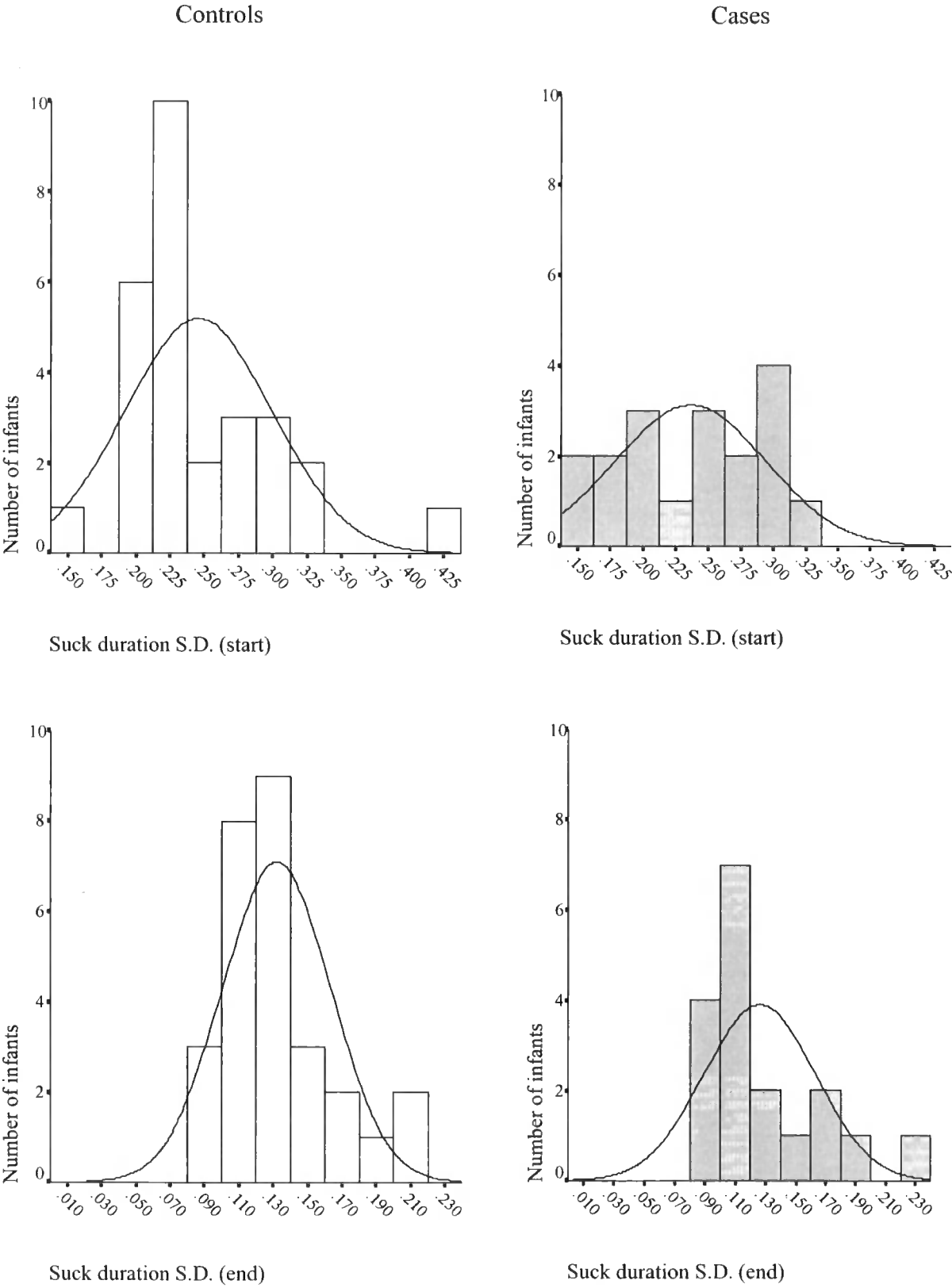


Figure 5.6 **Distribution of the mean pause length for the start and end of the feed for cases (n=19) and controls (n= 30).**

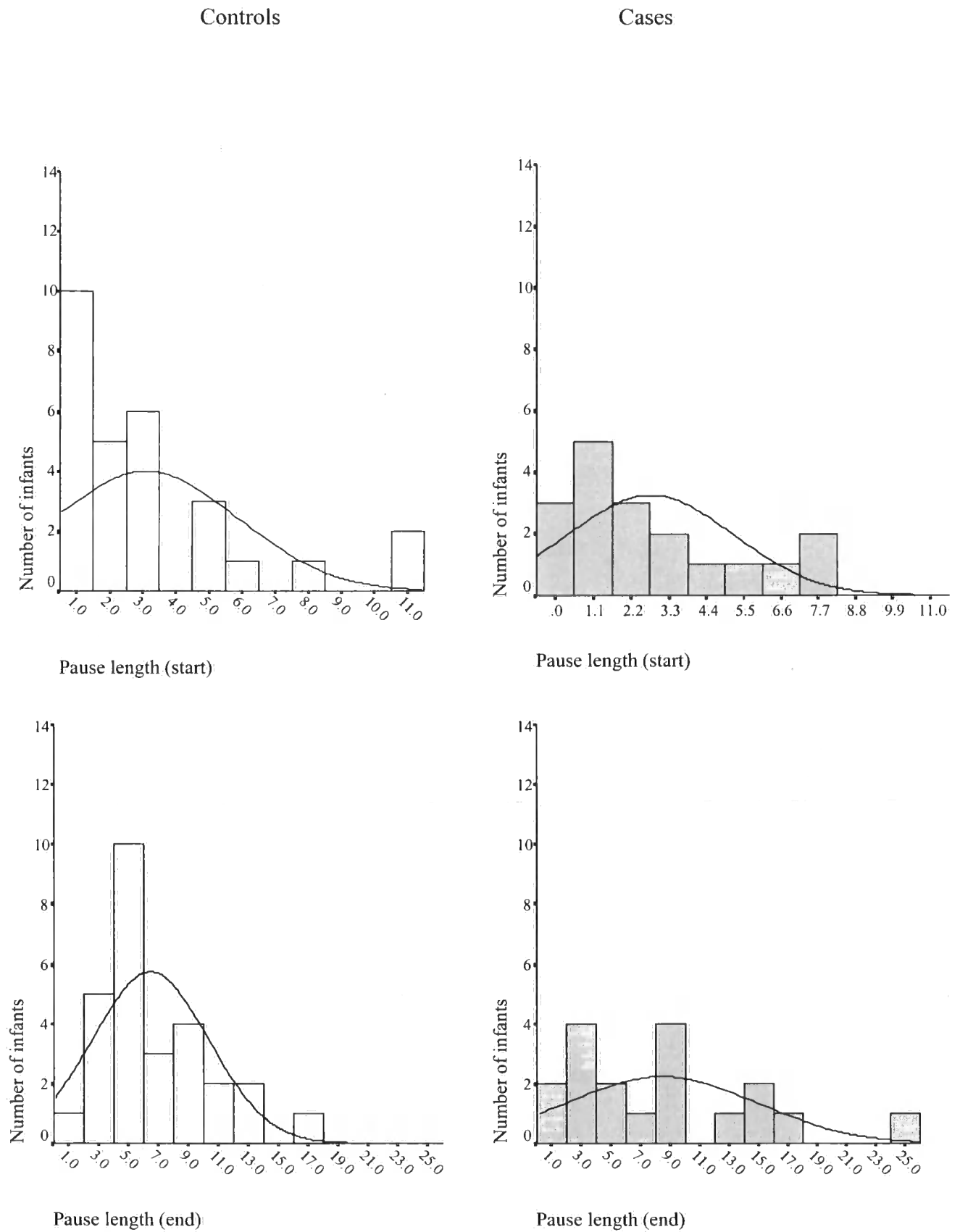


Table 5.2.1b Summary of U test for cases and controls for feeds

<i>Feeding behaviour</i>	<i>z value</i>	<i>df</i>	<i>p. (2-tailed)</i>
Sucks per burst (start)	-1.508	45	.132
Sucks per burst (end)	-1.148	45	.251
Suck duration (start)	-.923	45	.356
Suck duration (end)	-.428	45	.669
Suck duration, sd (start)	-.225	45	.822
Suck duration, sd (end)	-.968	45	.333
Pause length (start)	-.383	45	.702
Pause length (end)	-.765	45	.444

5.3 Exploring other feeding variables

A number of other measures were recorded in relation to the feeds. These were feed type, mass consumed at feeds and duration of feeds and weight of the infant at visit. Figure 5.7 is a frequency chart showing the feed type for cases and controls. The figure shows that bottle feeding was more common in controls than cases. Table 5.3a shows the proportion of infants that were breast and bottle fed according to group. A chi-square test was used to compare cases and controls. There were no statistically significant differences between the two groups.

We can now explore the mean the mean mass consumed and the mean duration of feeds within cases and controls. Figure 5.8 mean mass consumed by infants according to group, and Figure 5.9 shows the mean duration of feeds according to group. The

figures are useful for examining data visually, but they do not tell us anything about group differences. To examine group differences a t-test was used that compared cases and controls on mean duration of feeds and mean intake during feeds. There were no statistically significant differences for duration of feeds or intake.

Figure 5.7 Number of infants receiving breast or bottled milk during the observational study.

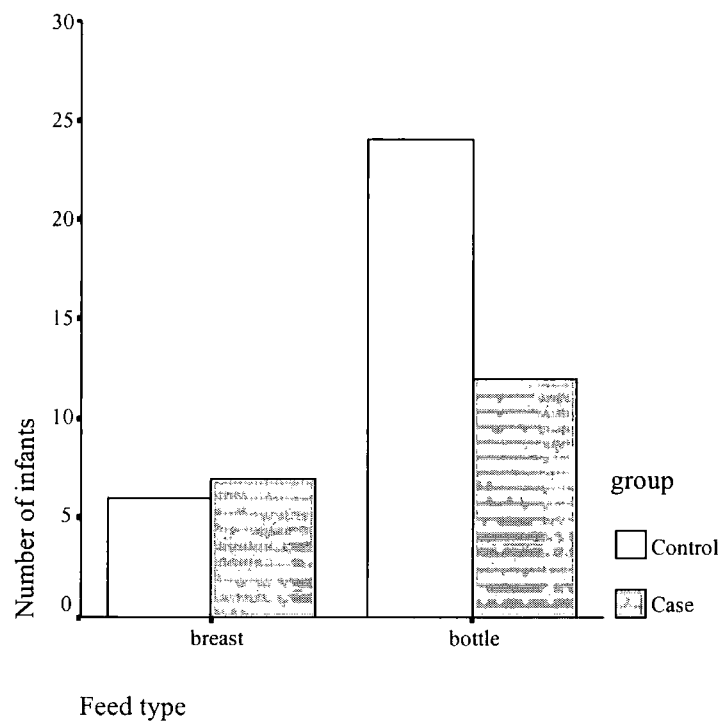


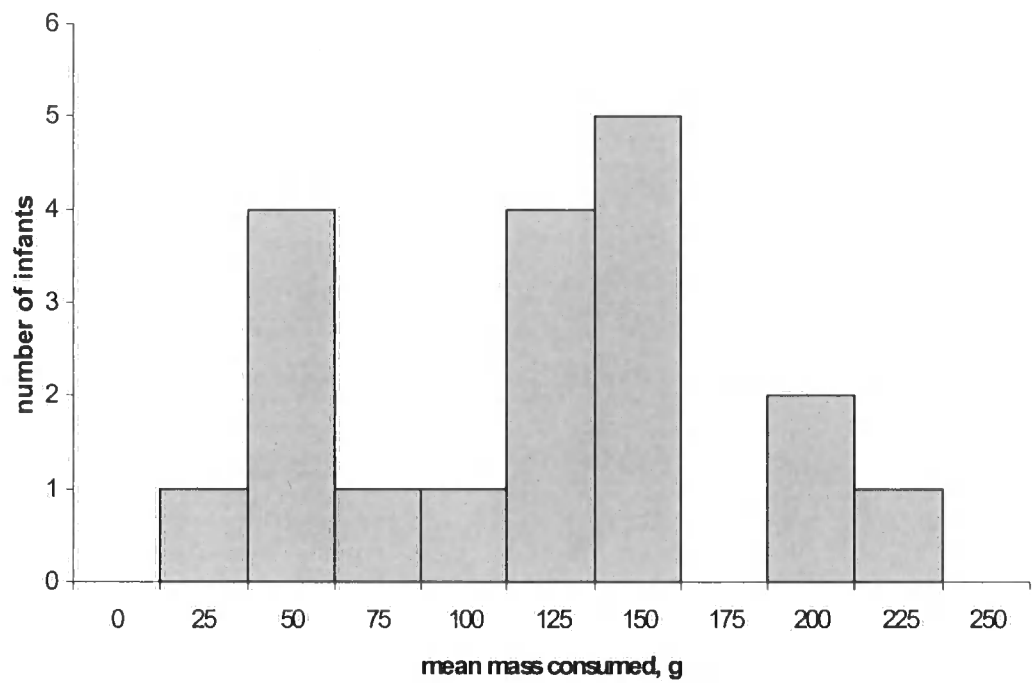
Table 5.3a Feed type in cases and controls

Feed Type	Cases		Controls	
Breast	7	(36.8%)	6	(20%)
Bottle	12	(63.2%)	24	(80%)
Total	19	(100%)	30	(100%)

Chi-square = 1.69, df = 1, p = .19

Figure 5.8 Mean mass consumed according to group.

Cases



Controls

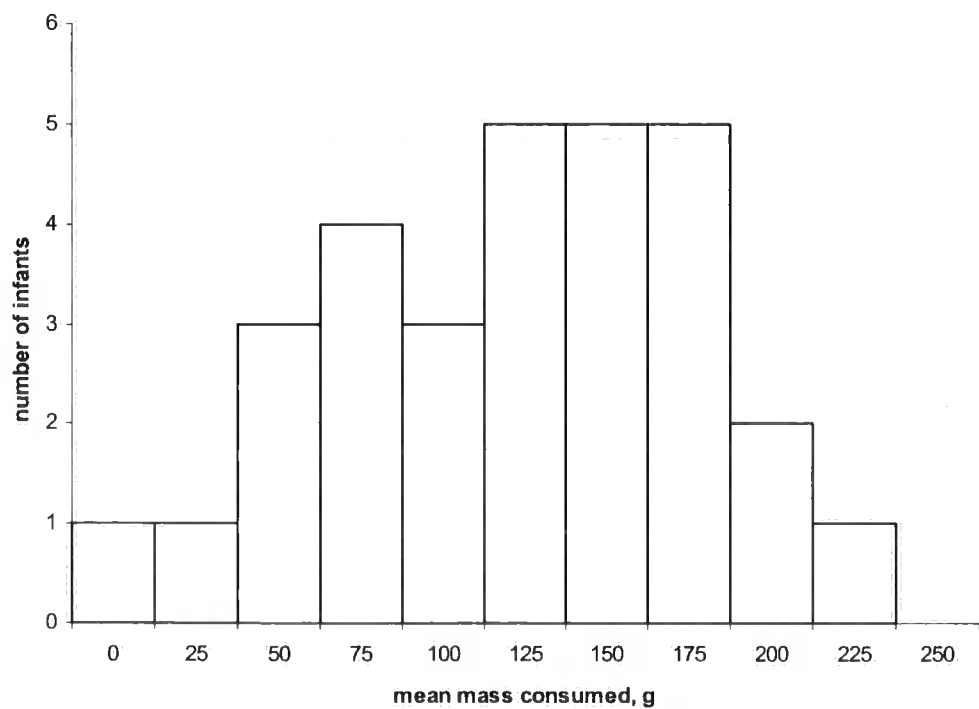
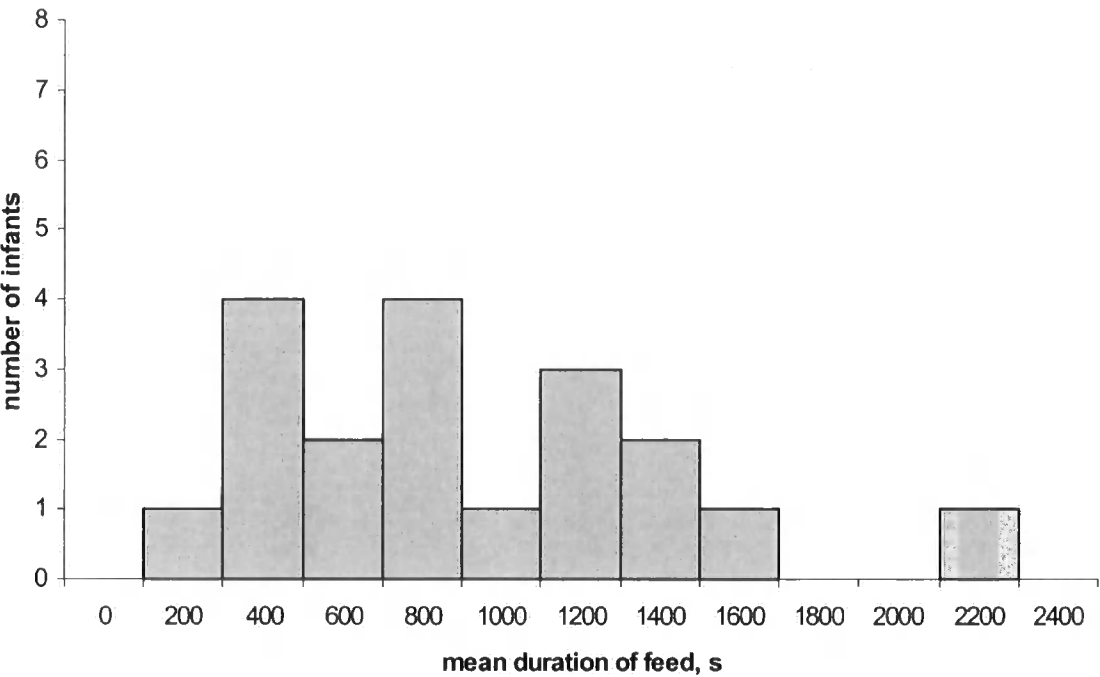


Figure 5.9 Mean duration of feeds according and group.

Cases



Controls

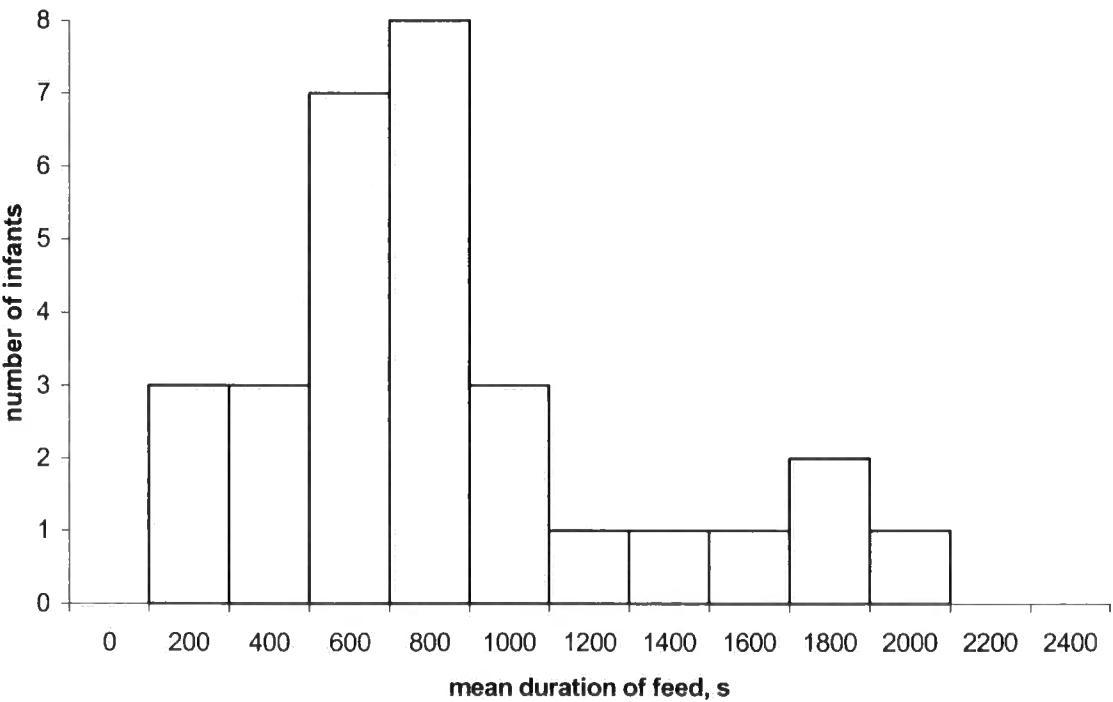


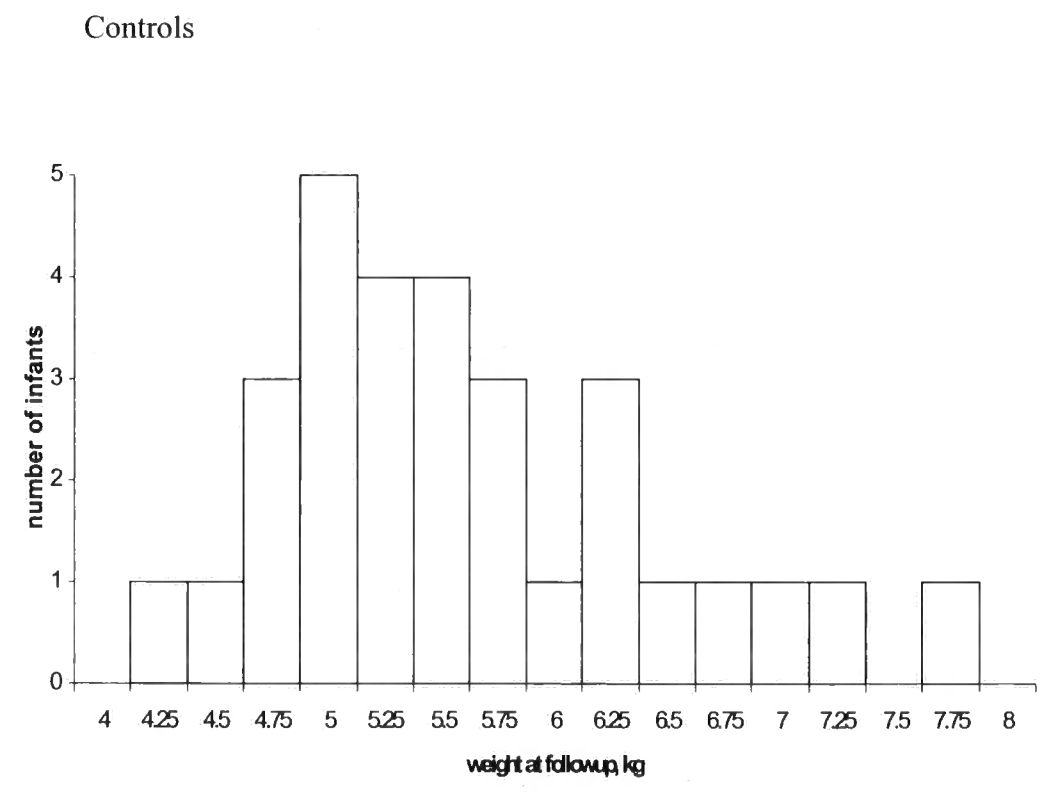
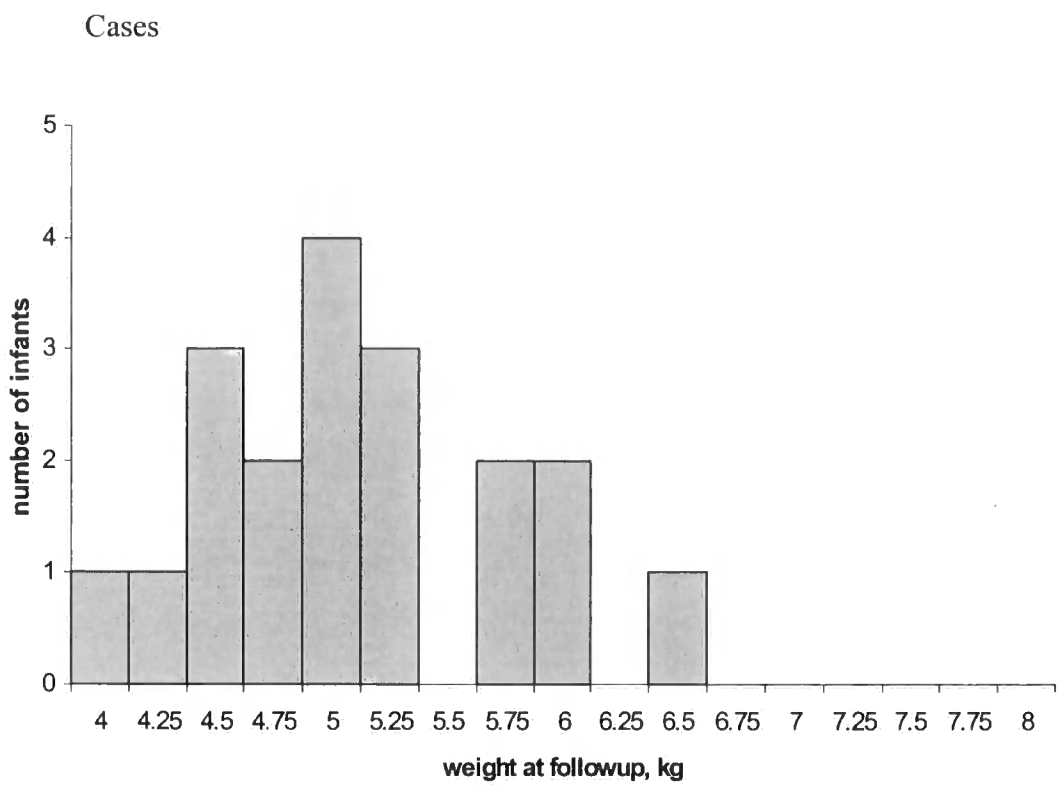
Table 5.3b T-test results for mean duration of feeds and mean mass consumed, for cases and controls

		<i>N</i>	<i>Mean</i>	<i>S.D.</i>
<i>Mean duration (s) of feeds</i>	Cases	19	1019.15	522.05
	Controls	30	956.84	461.28
		T= -.44 , df = 47 , p= .664		
<i>Mean intake (g) for feeds</i>	Cases	19	131.99	55.46
	Controls	30	132.56	54.87
		T= .04, df= 47 , p= .97		

5.4 Weight at visit and the influence of other variables

During the observational study the weight of the infant was taken. Figure 5.10 shows the distribution of weight at visit for cases and controls. Since the data was normally distributed, a t-test was used to compare the cases and controls. Table 5.4a shows a summary of the t-test results. There was a statistically significant difference between cases and controls. Cases were .49 kg lighter than controls.

Figure 5.10 Weight at visit for cases and controls



**Table 5.4a T-test results for weight during the observational study,
for cases and controls**

		<i>N</i>	<i>Mean</i>	<i>S.D.</i>
<i>Weight at follow up (kg)</i>	Cases	19	5.25	.65
	Controls	30	5.74	.84
		T= 2.12, df= 47, p= .039		

However, weight can be influenced by a variety of factors such as feed type, sex, intake etc. The next part of the analyses is to investigate how each of these feeding variables and the sucking parameters interact with each other. The question we wanted to know was whether there was a difference in weight at the follow up that could be predicted by one or more of these variables. In order to do this, a hierachical regression was used that included the feeding variables, plus birthweight and sex.

These feeding variables may influence weight gain, and the purpose of this analysis was to investigate each variable separately, studying the influence of each on weight gain. The influence of each variable was analysed step by step in a hierachical regression analysis with weight as the dependent variable

1. with birthweight and sex
2. adding feeding method
3. adding the sucking parameters
4. adding the mean mass consumed at feeds and the mean duration of feeds

A hierarchical regression assesses the significance of each independent variable (summarised above) in relation to the dependent variable (weight). Each variable is entered in a sequence and its value is assessed. Table 5.4b shows a model summary. The model summary shows the contribution that the significant independent variables have on weight. The model summary is a useful tool for examining the contribution of each of the selected variables. For example, the R^2 value can be converted into a % that tells us how much of the variance a particular variable accounts for. From the table it can be seen that the sex and birth weight variables account for 47% of the variance; feed type accounts for 6.8% variance, and the sucking parameters for 10.7% variance and the mean mass and duration of feeds for 1.1%.

Parameters are shown in table 5.4c. The table shows a summary of the statistically significant variables (i.e. sex, birthweight and feed type) and the remaining variables that were excluded from the final model because they were not statistically significant. The table shows that none of the feeding parameters, the duration or milk intake were significantly related to weight of the infants during the observational study. The anova at the end of the table shows the final test results for the regression analysis that includes sex, birthweight and feed type. These variables were predictors of weight gain at eight to twelve weeks of age ($R^2 = .51$, $F = 16.85$, $p = .000$).

Table 5.4b Change statistics for weight gain from birth to observational study on sex, birthweight, the feed type, sucking parameters and mean mass consumed and mean duration of feeds

Change statistics						
Model	ΔR^2	r^2	F ch	Δdf regression	df residual	p
1.						
Sex & Birthweight	.454	.478	19.71	2	43	.000
2.						
Feed type	.514	.068	6.29	1	42	.016
3						
Sucking Parameters	.541	.107	1.31	8	44	.270
4.						
Mass & Duration Of feeds	.529	.011	.55	2	32	.584

Table 5.4c Regression analysis of weight gain to the observational study on birthweight, sex, feed type, sucking parameters and mean mass and duration of feeds.

	B	t	p		
<i>Statistically significant variables</i>					
Constant		7.58	.000		
Sex	-.49	-4.33	.000		
Birthweight	.41	3.62	.001		
Feed type	.26	2.51	.016		
<i>Excluded Variables</i>					
Sucks per burst, start	.06	.54	.591		
Sucks per burst, end	-.08	-.74	.461		
Suck duration, start	-.17	-1.54	.130		
Suck duration, end	-.07	-.57	.571		
SD suck duration, start	-.17	-1.52	.136		
SD suck duration,end	.11	.94	.351		
Pause length , start	-.01	-.06	.952		
Pause length ,end	-.13	-1.17	.250		
Mean mass of milk consumed	.11	.91	.368		
Mean duration of feeds	.16	1.43	.160		
<hr/>					
<i>Analysis of variance</i>					
	Df	Sum of squares	Mean square	F	p
Regression	2	15.88	5.30	16.85	.000
Residual	42	13.20	.31		
Total	45	29.09			

5.5 Reconstitution of milk samples

During the course of the observational study, samples of formula milk were collected prior to each bottle feed. These samples were analysed for their dried matter content. The specific question asked was whether mothers are consistent in their preparation of formula, and whether the reconstituted formula milk of cases differed to that from controls. The samples were analysed by Dr. Chris Seal at the Department of Human Nutrition at Newcastle University. Chapter two described the procedure used for analysing the samples. Briefly, this required reconstituting samples of each brand of formula milk and assessing the quantity of dried matter that should be present in a correctly prepared feed (Standard Measure or SM). This was compared to the amount of dried matter that was found in the feeds prepared by mothers who participated in the follow up study (Follow up Sample Measure, FSM). A ratio of mothers' feed (FSM) to correctly prepared feed (SM) was calculated:

$$\text{Ratio of FSM to SM} = \frac{\text{Dried matter present in sample (FSM)}}{\text{Expected quantity of dried matter (SM)}}$$

For example, the expected quantity of dried matter in correctly reconstituted SMA Gold formula is 12.11mg per 100 ml of formula. If a sample of SMA Gold prepared by a mother contained 12.11 mg of dried matter per 100 ml; the calculated ratio of FSM to SM is 1.0. If a sample of SMA Gold prepared by a mother was 11.92 the ratio of FSM to SM is .98.

For each bottle fed infant, a ratio of the dried matter was calculated for each feed, i.e. there were two separate ratios of FSM to SM. Table 5.5a shows a summary of the mean ratio of dried matter (mean ratio for the two feeds) according to brand. Since the numbers available for analysing differences for individual brands was small, the table shows the brands grouped according to manufacturer. For example, 'Cow & Gate' produce 'Plus' and 'Premium'. These two brands have been grouped together in the table. The table shows that the most accurately reconstituted brand is SMA (Gold & White) by mothers of cases. The least accurately prepared brand is Farley's (First & Second) by mothers of controls. There were no mothers of cases who used this brand of milk.

Table 5.5a Mean ratio for dried matter found in milk to standard measure

<i>Brand</i>	<i>Cases</i>		<i>Controls</i>	
	<i>Mean ratio</i>	<i>S.D.</i>	<i>Mean ratio</i>	<i>S.D.</i>
Cow & Gate	1.05	0.11	1.02	0.08
Farley's (First & Second)	n.a	n.a	0.93	0.08
SMA (Gold & White)	0.99	0.12	1.02	0.10
Milupa (Aptimil & Milumil)	0.82*	n.a	1.02	0.306

n.a. denotes non applicable; no mothers used this brand

* only one case infant consumed this brand and an S.D. is therefore not available

There were two main questions concerning the milk sample data. Firstly, are the mothers consistent in their preparation of formula milk from the first fed to the next? If the mothers were not consistent, this would suggest that they are not taking much care

in the preparation of formula milk. If they were consistent it would suggest that there is some careful consideration that goes into preparing their infants' feeds. The next question was whether there was a difference between cases and controls in the preparation of formula milk. The analysis for each of these questions are detailed below.

Firstly, *are mothers consistent in the way they prepare formula from one feed to the next?*

Table 5.5b shows Pearson correlations across the two feeds. The table shows that there was a statistically significant correlation between the two feeds and quite high. The results of this analysis show that mothers are reasonably consistent in the way in which they prepare formula milk across feeds.

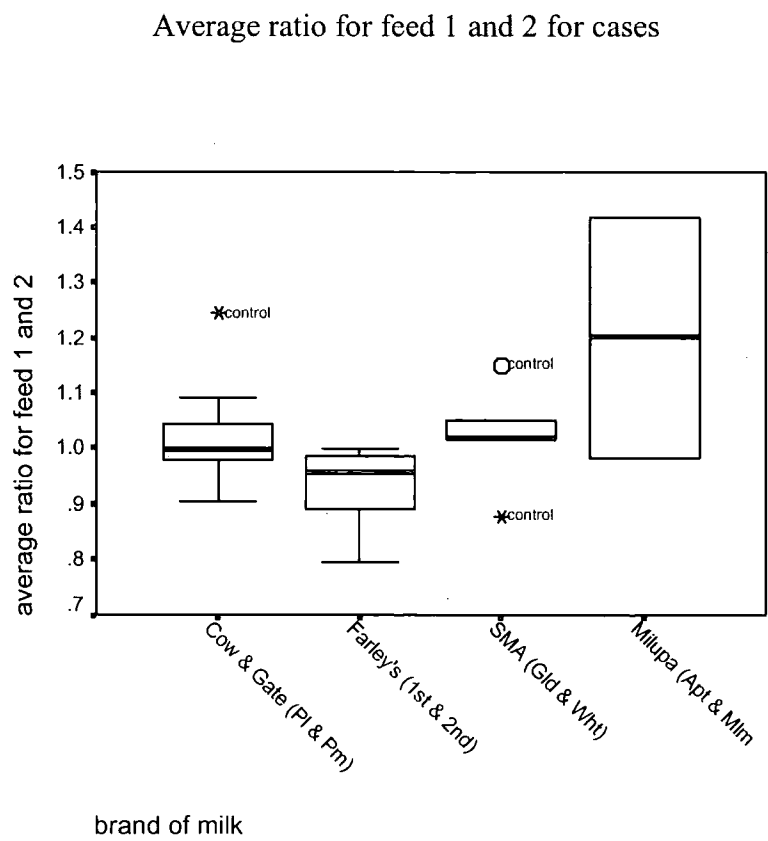
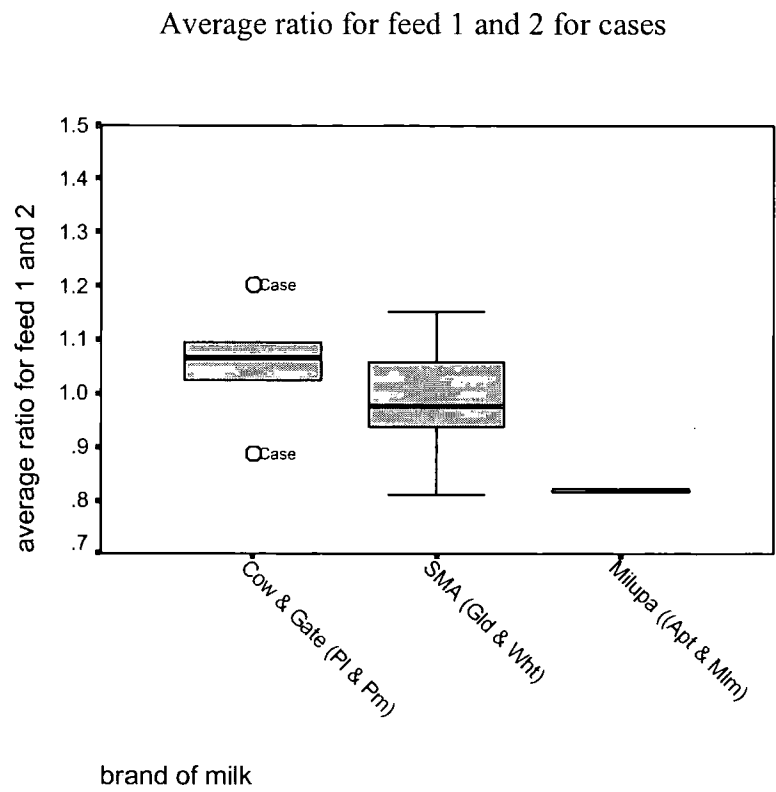
Table 5.5b Correlation of reconstituted formula ratios for feed 1 and feed 2					
	<i>N</i>	<i>Pearson r</i>	<i>p.</i> <i>2 tailed</i>	<i>Mean</i>	<i>S.D.</i>
Feed 1 mean ratio	36			1.013	.126
Feed 2 mean ratio	36			1.006	.134
Correlation	36	.693	.000		

The second question investigated was: *do mothers of cases and controls differ when reconstituting formula milk?*

Figure 5.11 shows the distribution of the calculated ratios of reconstituted formula according to brand. The mean ratio for both feeds was plotted against group, with each brand of formula milk identified. We expected some variation in the formula preparation. The chart shows that there is a lot of variation in the re-constitution of Milupa by mothers of control infants. This is because there are only two data points available for controls consuming Milupa. Only one case infant consumed Milupa. To investigate these ratios further a t-test was used and there was no statistically significant difference between the two groups in terms of reconstitution of formula milk (Table 5.5c shows the t-test results).

<div> Table 5.5c T-test results comparing mean ratios for two feeds in cases and controls </div>			
	<i>N</i>	<i>Mean</i>	<i>S.D</i>
Cases	12	1.00	.12
Controls	26	1.02	.12
T = -.37, df = 36, p = .714			

Figure 5.11 Distribution of mean ratio for reconstituted formula for cases and controls.



The formula milks consumed by cases were Cow & Gate, Milupa and SMA. The ratio for Milupa is difficult to view because only one case infant consumed Milupa. For controls the milks consumed were Cow & Gate, Milupa, SMA and Farley's.

5.6 The feeding diaries

The final series of analyses for this chapter examines the data from the milk diaries. Mothers reports of the feeding experience are valuable sources of information. These diaries were used to investigate case and control differences further. Also the information contained in the diaries were compared with that collected by the experimenter to see if the feeding data collected was representative of the infants' general feeding behaviour. The milk diary was a record of the infant's feeds 48 hours prior to the day of follow up. The data contained in the diary was the time and duration of each of feed. If the infant was bottle fed, the mother was asked to record how many ounces were consumed by the infant. This was done by examining the feeding bottle at the end of each feed and estimating how many ounces had been consumed. If the infant was breast fed, this information was unavailable. The mother was also asked to record any problems encountered during each recorded feed. These problems could include, crying, refusal of feed, vomiting or falling asleep during feeds. Below is an example of a completed diary for a bottle fed infant.

Table 5.6a Feeding diary for bottle fed infant

Date & Time	What given?	How long fed for (minutes)	How many ounces (if bottle feeding)	Any comments/problems
19.11.99				
07.30am	C & G	25	6	None
11.45am	(& rice)	35	6	None
15.50pm	(& rice)	40	6	None
19.30pm	C & G	20	6	None
20.11.99				
07.00am	C & G	35	6	None
11.30am	(& rice)	40	6	None
16.30pm	(& rice)	30	6	None
19.30pm	C & G	25	6	None

This infant was fed Cow and Gate Premium milk at all feeds. However for four feeds within the 48 hour period, an additional supplement of rice was given (i.e. & rice). For all feeds, either with or without rice, the mother estimated that 6 ounces of milk were consumed. The mother reported no problems during any of the feeds.

Mothers of four infants failed to complete the feeding diaries correctly. Two of these mothers failed to return the milk diaries, explaining that they had misplaced them. Mothers of two infants (one case, one control) failed to complete the duration column.

A few infants were receiving complementary feeds. Complementary feeds were very rare within the data set (n=4) and were all bottle fed infants. Table 5.6b shows a

summary of the case and control infants receiving complementary feeds. The table shows that only one male case received complementary feeds within a forty eight hour period, compared to three control infants.

Table 5.6b **Complementary feeds in cases and controls**

<i>Sex/Group</i>	<i>Complementary Feed</i>	<i>No. of times in 48hours</i>
Controls		
Female	Baby rice	4
Male	Baby rusks	4
Male	Rice/ pure fruit puree	3
Cases:		
Male	Baby cereal	2

The milk dairy data was organised to determine the characteristics of a 48 hour feeding cycle for cases and controls. The average duration of each feed was calculated, and the average intake calculated. The frequency of problems reported was calculated for each infant. Table 5.6c shows a summary of the means and standard deviations for each group and a series of t-tests for mean number of feeds, duration and intake and a Mann-Whitney test for the average number of feeds in which problems were reported. The table shows that there was no statistically significant difference between cases and controls on any of the reported variables.

Table 5.6c Means and standard deviations for the reported number of feeds, feed duration, and volume consumed over 48 hours. The average number of feeds in which problems were reported is also shown.

	<i>Mean</i>	<i>SD</i>
Mean number of feeds per 48 hours		
Cases	15.63	5.82
Controls	12.93	5.49
$t = -1.50, df = 41, p = .14$		
Recorded feed duration (m)		
Cases	21.19	7.89
Controls	21.22	11.09
$t = .009, df = 41, p = .99$		
Recorded volume consumed (g)		
Cases	123.56	38.22
Controls	139.67	35.86
$t = 1.27, df = 34, p = .21$		
Average number of feeds in which problems were reported		
Cases	0.89	1.26
Controls	1.01	1.50
$Mann\text{-}Whitney = 203.00, z = -.149, p = .88$		

The next question was how reliable are the data contained within these feeding diaries. To analyse this the feed duration and volume consumed, as reported by mothers, was correlated with the objectively recorded feeding behaviour collected by the experimenter. Feed time and volume consumed as reported by the mother and as measured by the experimenter was compared. For the duration of feeds, both breast and bottle fed data were included in the analysis; for the mean intake of milk, only bottle fed infants were used in the analysis. Figure 5.12 shows the reported feed time and objectively recorded feed time for case and control infants. Two mothers failed to complete this particular part of the feeding diary, and therefore their data was excluded from the analysis. A regression line showing the relationship between the two variables has also been plotted. The second graph within figure 5.12 shows the reported and objectively recorded data for milk intake. Two mothers failed to complete this section of their feeding diary and their data has been excluded from this analysis. A regression line has also been plotted to identify the relationship between the two variables. These graphs provide a descriptive means of interpreting the data. To find if there is a correlation between the two variables a correlational test was used. Table 5.6d shows the Pearson correlation coefficients. The table shows that the reported and the observed feed time and duration were both significant. The table shows that there is a strong correlation between the reported behaviour and the behaviour objectively recorded. This is a significant find. The mothers have provided a record of how their infants feed during a 24 hour period and this correlates with data objectively recorded for two consecutive feeds. This means that the data objectively recorded is representative of the infants feeding behaviour.

Figure 5.12 Graphs showing reported and objectively recorded time and intake in cases and controls.

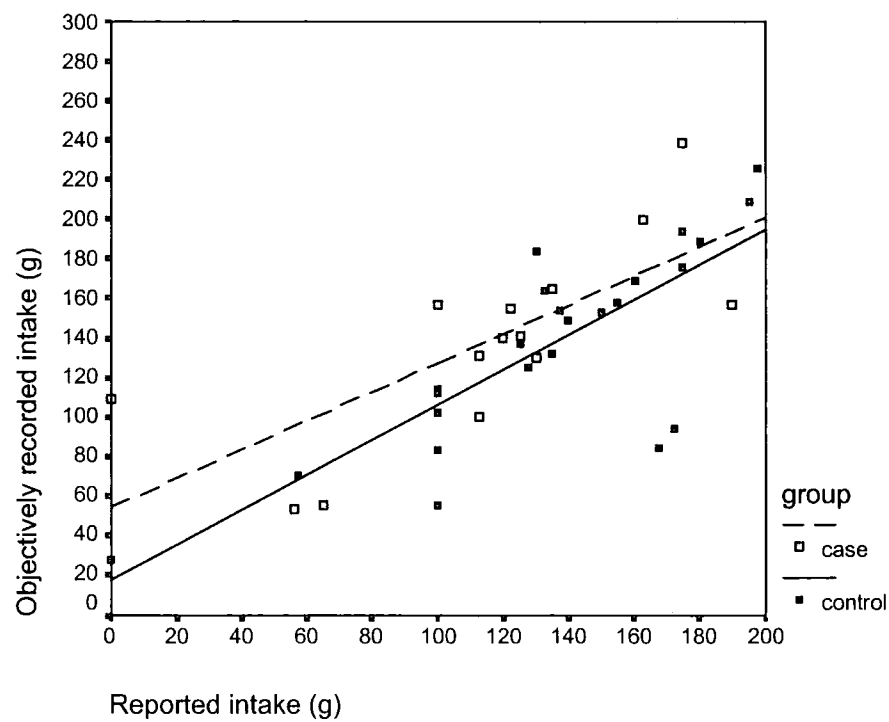
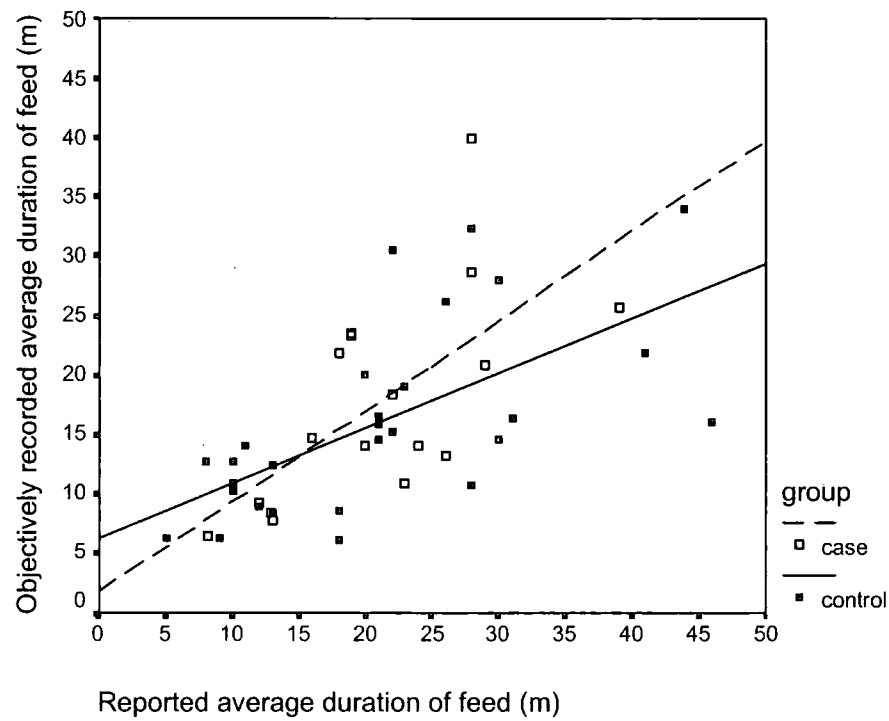


Table 5.6d Results of Pearson correlation investigating reported feed time and volume consumed with the observed data (collected by the experimenter) for these measures.

	N	Pearson	p
Reported feed duration & objectively recorded duration	47	.63	.00
Reported volume consumed & objectively recorded consumed	33	.71	.00

5.7 Summary

This chapter has examined the feeding behaviour of infants that was collected objectively by the experimenter when the infants were aged between eight and twelve weeks. It was anticipated that there would be some feeding differences between cases and controls. However, the data collected and analysed here suggests that there are no statistically significant differences between the feeding behaviour of cases and controls. There was no difference in the sucking behaviour, mass consumed, duration of feeds, reconstitution of formula milk or the reported feeding behaviour by mothers. The weight objectively recorded during the observational study, was the only statistically significant variable with cases being lighter than controls. This was of course part of the selection criteria for identifying cases and controls.

The feeding behaviour reported by mothers was significantly correlated with that observed by the experimenter i.e. duration of feeds and volume consumed during feeds.

This is a valuable finding, since the next chapter deals with reported feeding behaviour. The feeding questionnaire was completed at the same time as the cases and controls were identified using the Thrive Index as a screening method (infants aged approximately six weeks). It may be the case, that feeding behaviour differences were reported in this questionnaire, but were no longer apparent when a selection of infants were followed up between eight and twelve weeks, as reported in this chapter.

Chapter 6 :

Weight gain over the first year

Chapter 6

Weight gain over the first year

6.1 Introduction

The previous results chapters have given details of how the case and controls infants were selected using the Thrive Index with a birth weight and six week weight. The familial characteristics of the cases and controls were also analysed in Chapter Three. Chapters Four and Five analysed the feeding data.

This is the final results chapter of this thesis and it is divided into three sections. The first section is a summary of the weight data available for the analysis of growth during the first year. The differences in the way case and control infants gain weight during the first year were examined. The second section examines whether cases identified at six to eight weeks have sustained poor growth to twelve months, which is a conventional criterion for failure to thrive. Finally the third section examines the relationship between feeding variables and weight gain. The feeding variables used for the analyses in this section were the feed type, sucking parameters, milk intake and duration of feeds. This allows examination of early infant feeding characteristics that may be associated with weight gain.

6.1.1 The weight data available for research

Chapter Two described the procedure for collecting weight data. The weight data originated from questionnaires that were sent out to mothers at the time of routine health checks. Figure 6.1 shows the number of subjects from whom weight data was available from birth to twelve months. By the end of the first year, there was weight data for 79% of cases and 83% of controls. Although these figures are not as high as would be ideal, they are reasonably good. Weight data were missing at about twelve months for 21% of cases and 17% of controls. This was due to one of two reasons: either the families had withdrawn from the study or the families could not be traced. For these infants, the next available weight was used within a range of eight to 14 months. It is therefore not strictly accurate to describe all infants in the sample as having a 'twelve month' weight when clearly there was not a twelve month weight available for all infants. This chapter will refer to weight at the end of the first year, referring to data available from eight to fourteen months.

Figure 6.1 Summary of weight data available at about six weeks, four months and twelve months for case and controls infants

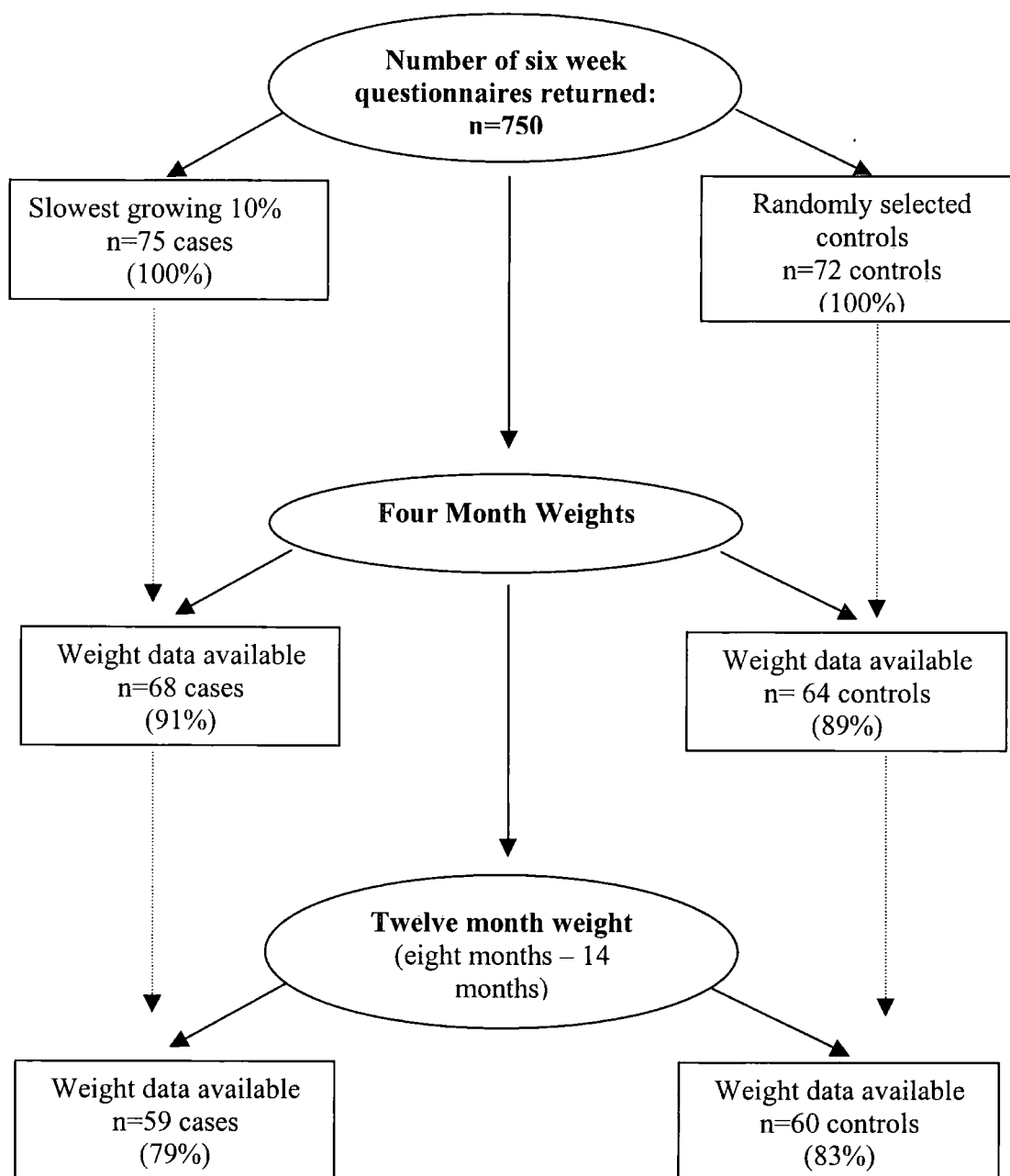
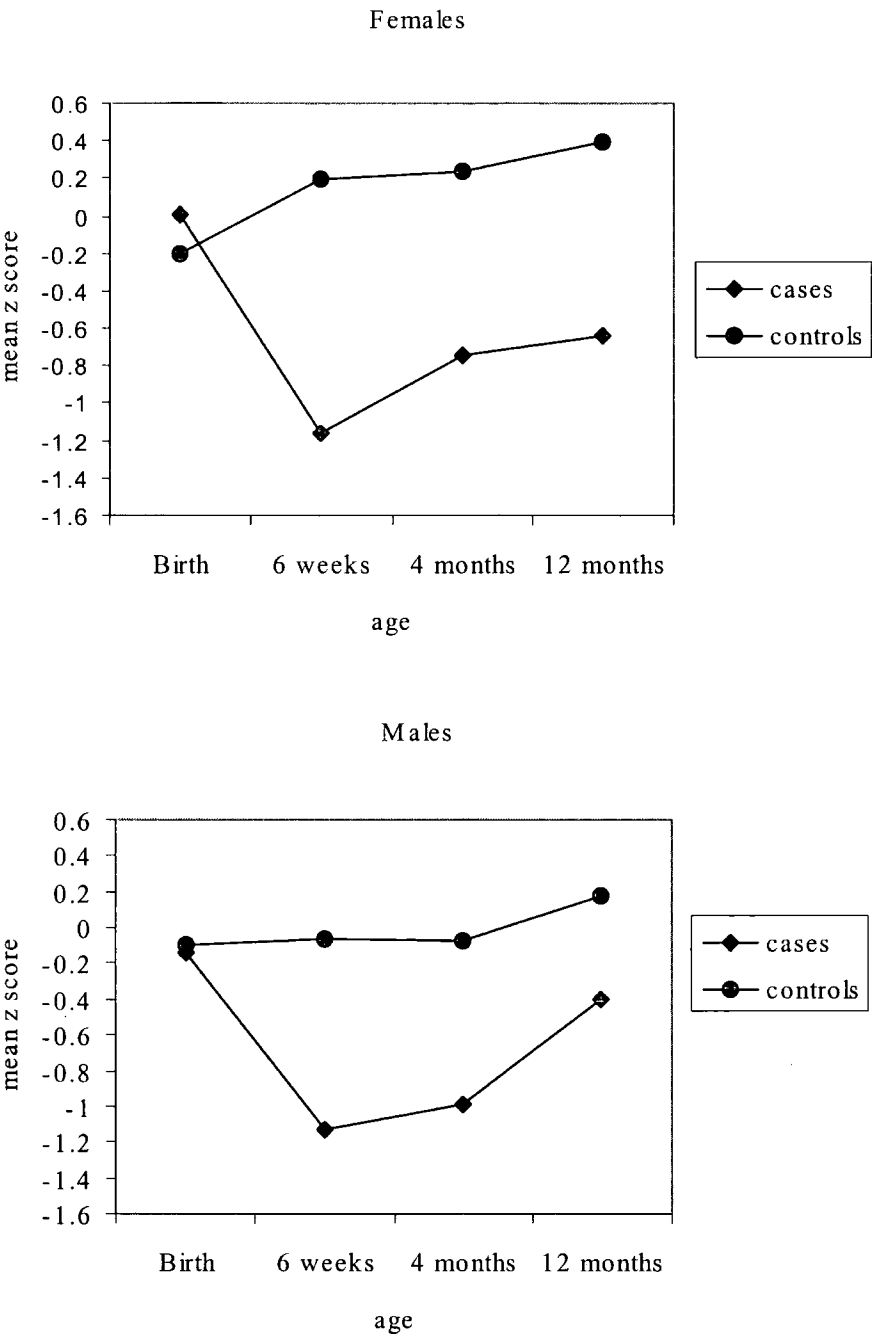


Figure 6.2 shows the mean z score for weight for cases and controls during the first year according to sex. The key points at which their weight was recorded are shown as birth, six weeks, four months and weight at the end of the first year. These z scores were used to monitor how the infant was gaining weight in relation to the British Growth Standard (Cole, 1990). If an individual infant's z score was 0 at a particular weight check, the infant had an average weight. If the z score was negative, the infant had a below average weight. If the z score was positive the infant had an above average weight. The figure shows that as expected, the female and male cases had below average weight, identified by the negative z score values except at birth. Female controls had above average weight at six weeks, four months and weight at the end of the first year, as shown by the positive z scores. Male controls have z scores that lie just below 0. This means that they had slightly below average weight during the first year although they were not in the slowest growing 10%. There is a larger gap in the growth of female cases and controls than in male cases and controls. This means that female cases had poorer growth than male cases, relative to their controls.

Figure 6.2 Growth trajectory of cases and controls from birth to twelve months.



6.2 Do cases identified at six to eight weeks fail to thrive over the first year?

This section examines the weight gain of cases and controls from birth to the end of the first year. By assessing the growth of infants to the end of the first year it is possible to assess the predictive value of identifying failure to thrive at six to eight weeks. This was achieved by identifying cases at twelve months and comparing these infants to cases identified at six to eight weeks. If cases identified at six to eight weeks continued to fail to thrive to the end of the first year, the thrive index at six weeks was a useful method for the early identification of cases who fail to thrive over the first year.

Section 2.5.1 describes the procedure for calculating the Thrive Index for cases and controls at twelve months. The z scores for weight at the end of the first year against birth weight z scores are shown in figure 6.3 for female cases and controls and figure 6.4 for male cases and controls. The 'average' line represents average weight of infants according to birth weight and the 'threshold' line represents the threshold at which the slowest growing 10% are identified. The threshold for both males and females was -1.3.

Figure 6.3 shows that at about twelve months there are two female controls below the threshold, and a number of cases now above the threshold. More cases than controls lie in the area between the 'average' and 'threshold' lines. Infants in this area have below average weight gain, but the weight gain is greater than in the slowest growing 10%. Figure 6.4 shows that there are four male controls below the threshold and a number of

male cases above the threshold. Ten female case infants and six male case infants lie below the threshold. These are infants who fail to thrive over the first year.

Figure 6.5 shows the distribution of the weights at the end of the first year for cases and controls. The mean end of year weight for controls was 10.39 kg and for cases 9.61 kg.

Figure 6.3 : Birth weight and 12 month z scores for female cases and controls as identified at the six week check.

The 'average' line represents average weight at one year, the 'threshold' represents the threshold for identifying the slowest growing 10%. This threshold is set at 1.3 S.D. below the 'average'.

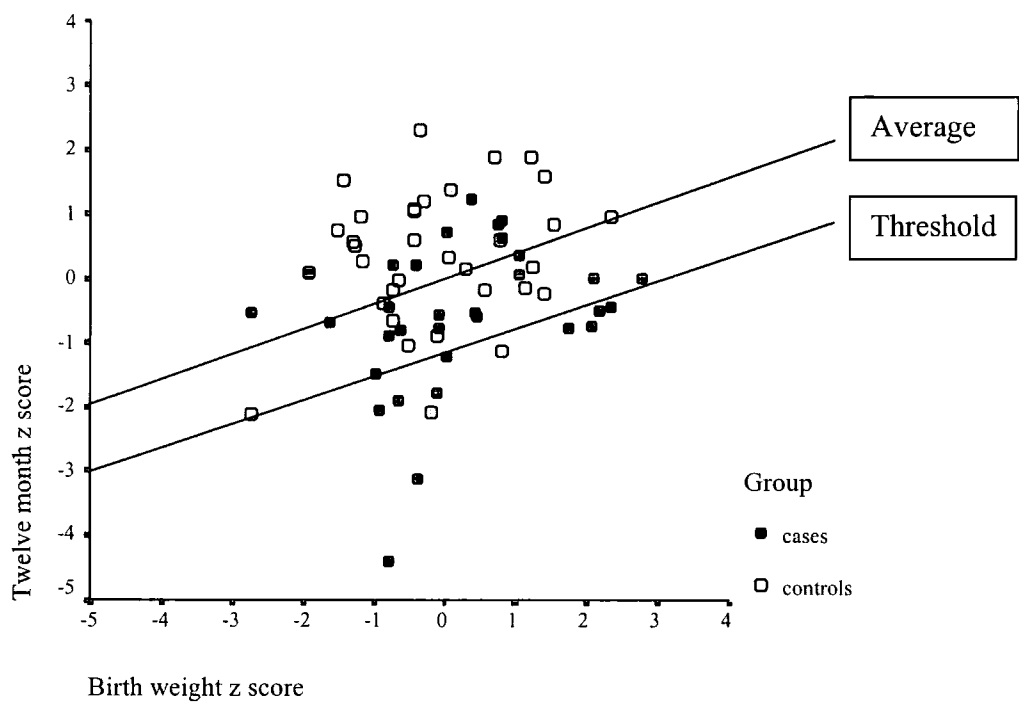


Figure 6.4 : Birth weight and 12 month z scores for male cases and controls.

The 'average' line represents average weight at one year, the 'threshold' represents the threshold for identifying the slowest growing 10%. This threshold is set at 1.3 S.D. below the 'average'.

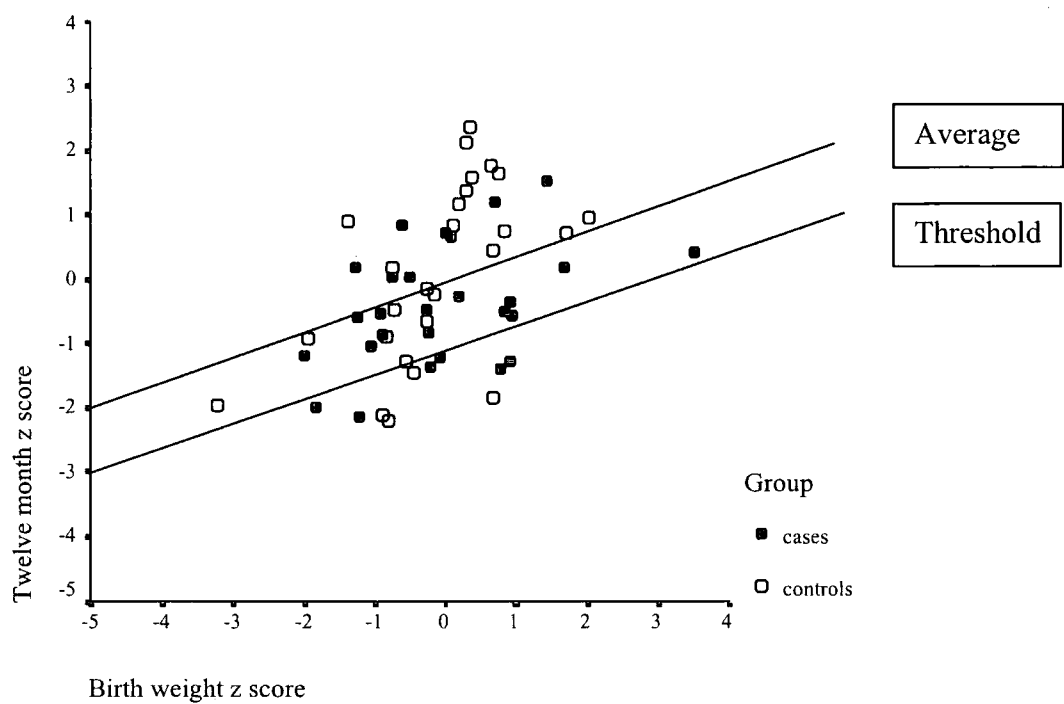
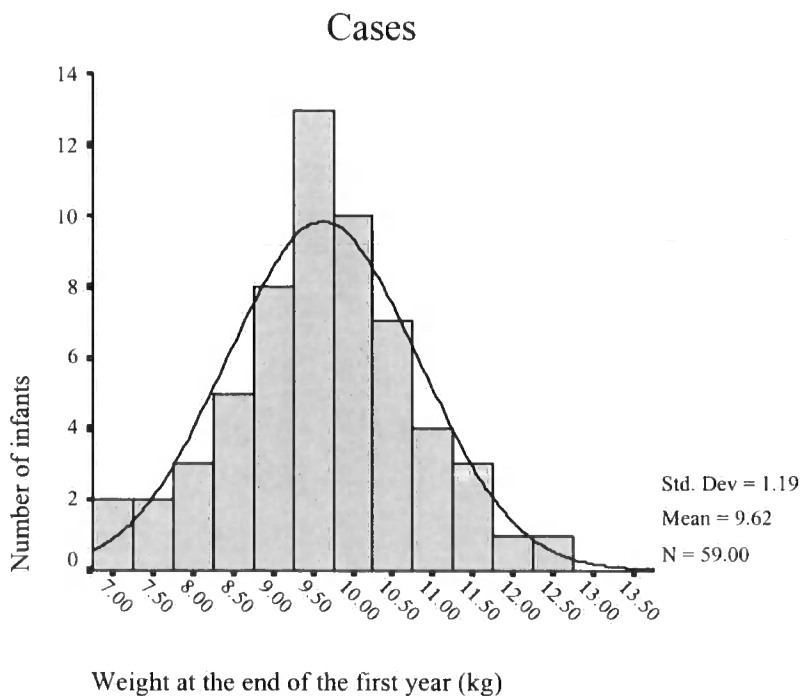
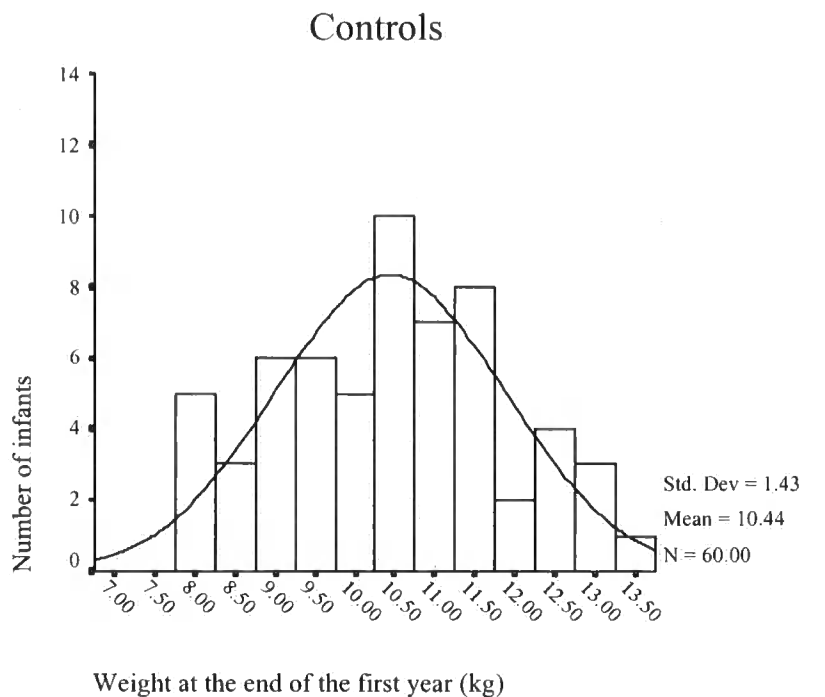


Figure 6.5 Distribution of weight at about one year in cases and controls



Weight gain is influenced by a number of different factors. An analysis was done to determine if weight at the end of the first year could be predicted by birth weight, sex, group and age. Age being age at the time at which the final end of the first year weight was taken. Table 6.2a shows a summary of the regression of the twelve month weight on birthweight, sex, status (case/control) and age. Only status was not significantly significantly related to weight at the end of the first year ($p=.065$).

Table 6.2a		Regression analysis of birth weight, sex and status on weight gain to the end of the first year.			
		Coefficient			
		B	Beta	t	p
Constant		5.827		3.819	.000
Birth weight (kg)		.597	.306	2.447	.019
Sex		-1.139	-.460	-3.669	.001
Status		.135	.054	.450	.065
Age (weeks)		.008	.459	3.708	.001
Analysis of variance					
	Df	Sum of squares	Mean square	F	p
Regression	4	29.002	7.251	7.812	.000
Residual	39	36.199	.928		
Total	43	65.201			

Table 6.2b shows a number of males and females from birth to twelve months and how their status has changed according to the new threshold for identifying cases at twelve months. Sixteen infants identified as cases at six weeks were still identified as cases at the end of the first year. There were six control infants identified as cases at the end of the first year. There is the possibility that other indicators in early infancy might predict the weight of infants at the end of the first year. In the following section this question is answered by drawing upon other measures taken in early infancy.

Table 6.2b Frequency of case and control status at six weeks and over the first year.	
	<i>Infants</i>
Cases still failing at the end of first year	16 (27%)
Cases gained adequate weight at end of first year	<u>43 (73%)</u>
	59 (100%)
Controls failing at the end of first year	6 (10%)
Controls gained adequate weight at the end of first year	<u>54 (90%)</u>
	60 (100%)

6.3 The influence of other variables on weight gain over the first year

The previous section described the growth of infants over the first year using the available weight data for all cases and controls. This section considers whether early feeding behaviour predicts weight at the end of the first year. The feeding variables used in the following analyses were those objectively measured during the observational feeding study, when the infants were aged between eight and twelve weeks (i.e. 19 cases and 30 controls). The sucking behaviour of the infants was taken from video tapes that were coded and analysed to estimate a series of parameters that characterise each feed:

Sucks per burst, start

Sucks per burst, end

Suck duration mean, start

Suck duration mean, end

Suck duration S.D., start

Suck duration S.D., end

Pause length, start

Pause length, end

The other feeding variables used were feed type, the mean mass of milk consumed at two feeds and the mean duration of the two feeds. These feeding variables, with birthweight sex, and age of infant, were used in a regression analysis to determine their predictive value for weight at the end of the first year. Figure 6.6 is a diagram summarising the data used in

the regression. The influence of each variable was analysed in stages in a hierarchical regression with weight as the dependent variable:

1. with birth weight, sex and age
2. adding feeding method, mean mass consumed at feeds and the mean duration of feeds
3. adding the sucking parameters

Table 6.3a shows the model summary for each of the three stages. The model summary indicates the contribution that the independent variables contribute to the variability of weight as indicated by the R^2 change statistic. Birth weight, sex and age (stage 1) accounted for 43.2% of the variance. Feed type, mean mass and duration of feeds (stage 2) accounted for an additional 2.8%. Finally, adding the sucking parameters accounted for 16.6% of the variance (stage 3). Step 1 produced the only statistically significant contribution to the model.

Figure 6.6 Procedure for incorporating variables to predict weight using regression analysis

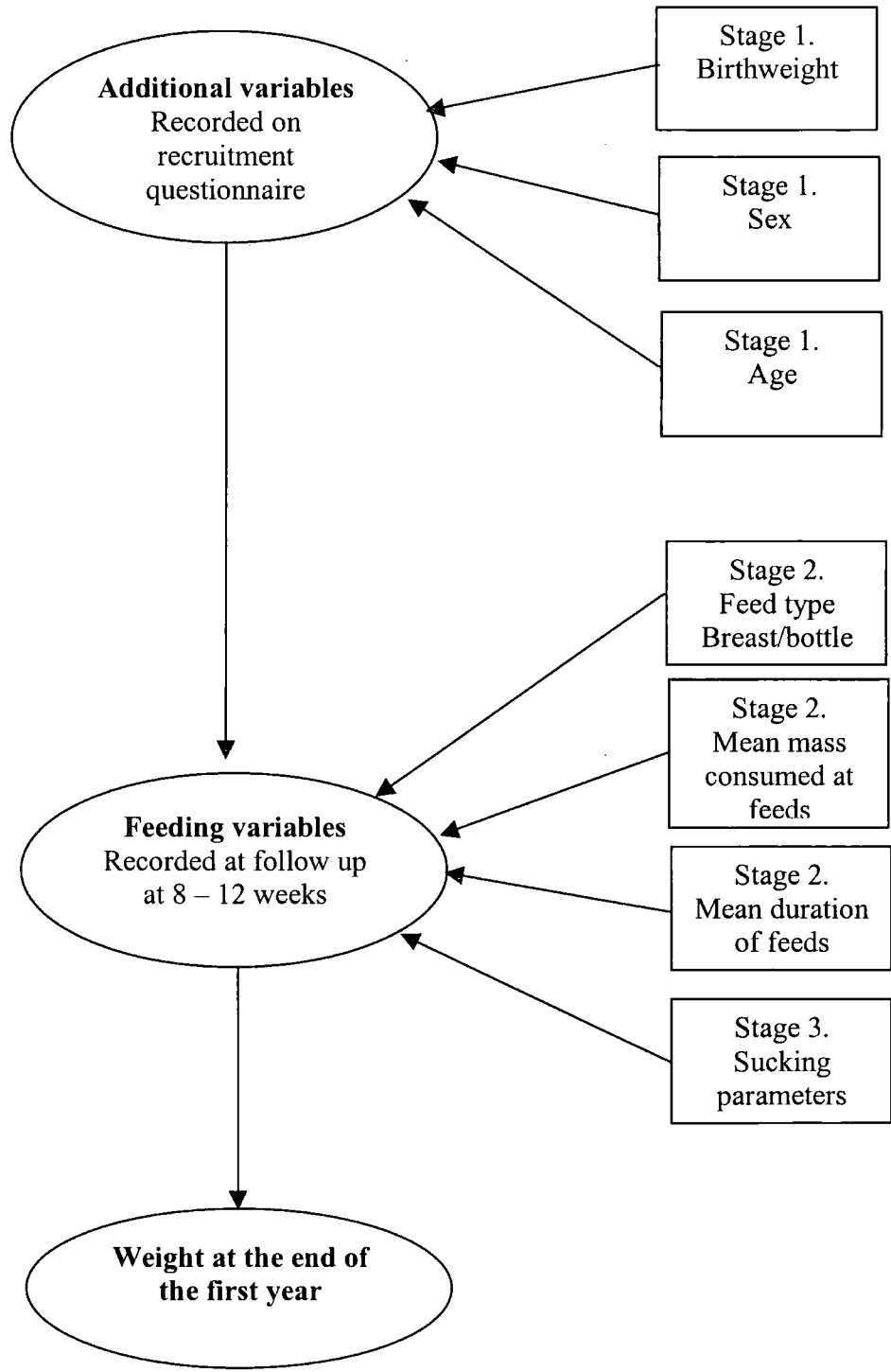


Table 6.3a Change statistics for weight gain from birth to end of the first year using Birth weight, sex, feed type, mean mass consumed at feeds (g), mean Duration (s) of feeds and sucking parameters.

Model	R ²	R ² _{Change}	Change statistics			p
			F _{Change}	df _{Change} regression	df residual	
Step 1						
Birth weight, sex & age						
	.432	.432	9.398	3	37	.000
Step 2						
Feed type, mean mass consumed & mean duration						
	.461	.028	.598	3	34	.621
Step 3						
Sucking parameters						
	.627	.166	1.450	8	26	.223

Parameter estimates can be found in table 6.3b. From the analyses shown, the statistically significant variables in the final regression stage were sex (p=.002), mean suck duration at the end of the feed (p=.038). However, the feeding variable is not significant when the number feeding variables tested was taken into account, this is indicated by the F_{change} statistic in table 6.3a which is not statistically significant (p= .621). Only sex can be considered as a predictor of weight at the end of the first year. Females are on average 516g lighter than males at the end of the first year.

Table 6.3b Regression analysis of birth weight, sex, age, feed type, mass and duration, and sucking parameters on weight gain to the end of first year.

	Coefficient				
	Beta	t	p		
<i>Constant</i>	<i>11.529</i>	<i>2.458</i>	<i>.021</i>		
Birth weight (kg)	.207	1.476	.152		
Sex	-.516	-3.354	.002		
Age (weeks)	.155	.764	.452		
Feeding type	.195	1.177	.250		
Mean mass (g)	.060	.300	.767		
Mean duration (s)	.078	.334	.741		
Sucks per burst, start	-.057	-.393	.697		
Sucks per burst, end	.274	1.763	.090		
Suck duration, start	.044	.235	.816		
Suck duration, end	-.608	-2.187	.038		
SD suck duration, start	.081	.412	.684		
SD suck duration, end	.345	1.562	.130		
Pause length, start	-.307	-2.022	.054		
Pause length, end	.076	.432	.669		
Analysis of variance					
	Df	Sum of squares	Mean square	F	p
Step 3					
Regression	14	37.995	2.714	3.125	.006
Residual	26	22.582	.869		
Total	40	60.576			

6.4 Summary

Of the cases identified at six to eight weeks, 27% of these continued to fail at the end of the first year. Although this is a small number, it is still large enough to suggest that identifying cases at six weeks is important because just over a quarter will have sustained poor growth over the first year. Of the remaining case infants that recovered, it must be noted that infants are susceptible to weight gain fluctuations during the first year of life. This has clearly been demonstrated in this thesis, since a number of controls identified at six to eight weeks became cases by the end of the first year and vice versa.

The final part of the chapter considered the predictive value of early infant feeding behaviour had upon weight at the end of the first year. Sex was the only statistically significant predictor of weight at the end of the first year. None of the feeding variables was statistically significant when the F_{change} statistic was taken into consideration. This means that early milk feeding behaviour was not related to weight at the end of the first year. This may be partly explained by the small numbers used in the analysis, and a larger group may have produced a significant effect. These results are discussed in more detail in next chapter.

Chapter 7:

Discussion

Chapter 7

Discussion

7.1 Introduction

There were four aims of this thesis. The first aim was to identify failure to thrive in early infancy using a Thrive Index (Chapter Three). The Thrive Index used provided a measure of the growth velocity of infants based upon two weights: birth weight and six week weight.

The second aim was to examine the familial characteristics of the case and control samples (Chapter Three). This would contribute to other research which has investigated failure to thrive in relation to socio-economic and other familial factors.

The third aim was to study feeding behaviour in infants who failed to thrive. This was done by considering reported behaviour from the mothers via a six week questionnaire (Chapter Four), and objectively collected data when the infants were eight to twelve weeks of age (Chapter Five). The reported and objective measures of feeding behaviour would optimise the amount of information that could be collected regarding these infants and offer a greater understanding of early feeding behaviour and growth.

The fourth aim was to monitor the growth of cases and controls over the first year and to determine if early recorded feeding behaviour predicted weight (Chapter Six). This was important because if growth were related to feeding behaviour, then long term poor growth would have to be sustained by certain feeding behaviour. Thus if early milk feeding behaviour was found to predict weight at the end of the first year, it would

suggest that characteristics of feeding observed in early infancy were sustained during the first year and influenced weight gain in that period.

The previous chapters analysed data in each of these areas and it was found that there were no statistically significant differences between cases and controls on their family characteristics, or the objectively recorded feeding behaviour at eight to twelve weeks. Analysis of the six week feeding questionnaire showed that case infants were more likely to be fed on demand and were more likely to be described as having a poorer appetite than that of controls. Furthermore, 27% of cases identified at six weeks continued to fail to thrive to the end of the first year. The final analyses reported in this thesis showed that sex was the only statistically significant variable that predicted the weight of infants at the end of the first year. Each of these findings is important when compared to previous research and make valuable contributions towards the planning of future research.

7.2 Identifying failure to thrive in early infancy

The first aim of this research was to identify failure to thrive in early infancy. This was achieved using a Thrive Index. The Thrive Index is a procedure for assessing growth velocity and uses two weights. For the purpose of this thesis the two weights were birth weight and weight at six weeks. The birth weight was obtained from the recruitment questionnaire and the six week weight was taken from the six week feeding questionnaire. Chapter three described the growth of infants according to their sex from birth to six weeks. The birth weight of case and control infants did not differ significantly but their weight at six weeks did. This means that birth weight was not a

variable on which the cases and controls differed. It was their post natal weight gain that determined whether a particular infant was a case or control.

This thesis used a Thrive Index to identify the slowest growing 10% of infants at six weeks of age. These infants were identified as failing to thrive and their growth subsequently monitored for one year and compared to that of control infants. The 10% criterion was used because infants are subject to growth fluctuations subject to e.g. minor infections. It was anticipated that the growth of all of the infants in the Millennium Baby Study would naturally fluctuate, so the slowest growing 10% as opposed 5% were selected as potential cases. This would take natural growth fluctuations into consideration, but allow infants with prolonged poor weight gain to be studied from birth to twelve months.

It could be argued that the lack of observed differences between cases and controls throughout this study may provide evidence of an over generous criterion used to identify potential cases. However, there are two possible answers to this. Firstly perhaps there were no differences between cases and controls to be observed. Secondly, chapter six contained details of how these infants grew over the first year. Of the 75 infants identified as cases 27% continued to fail to thrive at the end of the first year. Therefore using the Thrive Index to select cases at six weeks has shown that 27% of these cases continue to have poor growth at the end of the first year. This means that the Thrive Index is a useful means of identifying failure to thrive at six weeks and of these infants a significant number will continue to have sustained poor growth by the end of the first year.

7.3 Familial characteristics of cases and controls

The second aim of this research was to study the familial characteristics of case and control families, in particular whether the two groups differed in levels of deprivation. The term deprivation can be used to refer to either economic or emotional factors. This thesis focussed on demographic factors, which are more closely related to economic than emotional factors.

In order to discuss the findings of this thesis in relation to previous research the discussion will focus upon the evidence provided by studies in which relevant demographic factors have been mentioned. Economic factors refer to nature of employment, provision of housing, claiming of social benefits etc, and are often used as a means of matching case and control families while other factors are investigated, for example family violence (Crittenden, 1987) or mealtime behaviour (Hepstinall et al, 1987).

Research has also used different means of measuring economic deprivation. Certain studies have used ecological measures such as the location of the family within a particular area, while others have examined factors within the family to measure how poor the family is. Wright et al (1994b) used an ecological measure of deprivation. The frequency of poor growth was measured in affluent, intermediate and deprived areas of Newcastle. It was found that poor growth was more common in the deprived areas than the intermediate or affluent areas and sustained poor growth was identified at the end of the first year in deprived areas. However, the research also found that affluent areas contained a higher frequency of poor growth than intermediate homes. Wright et al (1994) suggest that this may be due in part to sustained breast feeding. In another study

(Kelleher et al, 1987) an investigation of risk factors associated with failure to thrive assessed the familial characteristics of case and control families. The study revealed that family income and marital status did not differ between the two groups. However mothers of infants who failed to thrive were more likely to have a college degree than mothers of controls. However, the study did find that cases were more likely to be developmentally delayed than controls.

This thesis examined demographic factors in cases and controls using within family measures as opposed to ecological factors. The data were recorded on the recruitment questionnaire in a section that asked mothers to provide information about their social circumstances. The questions concerned maternal education, wage earning, house/car ownership, religious affiliation and number of previous children.

7.3.1 Maternal education

The level of educational attainment is often referred to in studies of failure to thrive. Although not explicitly stated with the research it is implied that maternal education is an indication of parental ability. Previous research has found mixed results in this area. In a study by Black and Krishnakumar (1999) the mean number of educational years was lower in case mothers (10.76) than controls (11.40). Similar results were obtained from Hutcheson et al (1993) who found the mean number of educational years of case mothers was 10.60 and controls was 11.50. Kotelchuck and Newberger (1983) also found a trend in their data that suggested that case mothers were not as well educated as controls. Alternatively there is research that has found no difference in the educational attainment of cases and controls (Crittenden, 1987; Wilensky et al, 1996). Finally this

thesis reported no significant differences in the educational attainment of case and control mothers.

There are some similarities and differences in the design of these studies that may explain the discrepancy in the results. The sampling techniques may provide some indication of why the results differ so widely. Both Black and Krishnakumar (1999) and Hutcheson et al (1993) used low income based families for their investigation. Kotelchuck and Newberger (1983) used hospital referred cases and matched these infants with controls (i.e. age, race and sex) who were also attending hospital, although not for growth related problems. The problem with both of these studies is that the sample is not representative of the whole community.

Kotelchuck and Newberger (1983) do not describe the mean age of case and control mothers. This may be very important. If mothers of cases were younger than mothers of controls, and their infants had reoccurring or persistent failure to thrive since early infancy, the mother's opportunity to complete or pursue their education further would have been reduced compared to mothers of controls. The control mothers had infants with a 'spontaneous' easily treatable viral infection and many have had more opportunity to continue or pursue their education/vocational training than mothers of cases. In sum, the findings of Kotelchuck and Newberger (1983) must be considered with caution. Controlled community based studies provide a more powerful indication of maternal educational achievement in cases and controls.

Community based studies of failure to thrive have found no significant difference in the educational attainment of case and control mothers (Willensky et al, 1996; the findings of this thesis). These studies provide us with a more representative indication of failure

to thrive and educational attainment of mothers. Finally it is not only community based studies that find no significant differences between cases and controls. Crittenden (1987) used low income based families for research and found no differences between cases and control mothers in terms of education. What Crittenden did find was that failure to thrive mothers were better educated than mothers from families classified as maltreating or abusive.

There is one final point that needs to be made about educational attainment. If the level of maternal educational attainment is considered a guide to parental care, then the researchers must assume that the mother is the primary caregiver and her educational attainment is a reflection of her ability to provide adequate care. However the mother may not be the primary caregiver especially in a low income family since she may have financial pressure to return to work. The educational attainment of the father must also be examined. This thesis did not examine the educational attainment of the fathers, however Crittenden (1987) investigated this and found no difference between cases and controls. Kotelchuck and Newberger (1983) found no difference in the educational level of fathers of cases and controls. Mothers of failure to thrive infants had significantly less education when compared to their husbands, a discrepancy that was not evident in the control group. In sum it appears that sampling may account for some of the discrepancies in the results.

7.3.2 Wage earning, house and car ownership

A series of questions were concerned with wage earning, and house and car ownership. Collectively these variables can be considered as a measure of economic deprivation.

The wage earning variable determines if the family has an income, and the 'house' and 'car ownership' variables are indicators of whether the amount of disposable income a family has enables them to own a house or car. For each of these questions the responses of cases and controls were compared. There were no statistically significant differences for wage earning, house ownership or car ownership. In other words neither group was more or less affluent.

Relating these findings to previous research is difficult for two reasons: firstly sampling techniques have resulted in previous research using either low income families or referred cases, and secondly previous research have used different means of assessing deprivation within families. In one particular study (Nylander et al, 1989) the control infant families were classified as being slightly more affluent than the case families since there was no evidence in either parent of substance addiction or criminal records. Despite the difference in affluence the study found no differences between the children of case and control families in somatic illnesses, retarded psychomotor development or psychosomatic problems.

One problem with the wage earning criterion variable described in this thesis was that it did not tell us how much income per household was. If we had asked mothers to indicate what the mean annual income of the household it would have provided more information about the affluence of the families. Casey et al (1984) measured income per household and found that control families had a higher annual income (\$6188) than cases (\$5451). However they also measured income per capita and case families were better off (\$1273) than controls (\$1170). The results were explained by there being more people in the control homes (mean = 5.4) than the case homes (mean = 4.5).

Therefore income needs to be compared with the number living within the household to give a more accurate measure of how much disposable income a family has.

7.3.3 Number of previous children

Household density is a traditional measure of deprivation and the population of Britain are familiar with providing this information on the national census forms. Household density can be measured in a number of different ways. In this thesis the number of previous children was used as a source of information and it was found that there was no statistically significant differences between cases and controls. However this does not provide an accurate measure of density. For additional information the questionnaire should have asked how many persons there were living within the household and how many rooms within the household excluding kitchen and bathroom. Other studies have used number of people per household and found no statistically significant differences between cases and controls (Casey et al, 1984, Black & Krishnakumar, 1999). However, Kotelchuck and Newberger (1983) found a trend in the data that suggested case families live in fewer rooms. However if the mean number of persons within the household was considered there was a slightly higher mean (4.75) for controls than cases (4.29). This may explain why cases had fewer rooms but the families were smaller. Montgomery et al (1997) used a method more comparable with the national census using number of people per room excluding kitchen and bathroom and found that 44% of children with slow growth came from crowded homes compared to 16.4% from less crowded homes. This last study investigated short stature and not weight gain, which is disappointing in so much as it contained the most rudimentary

measure of density of all the above mentioned studies but does not include weight gain as a measure.

7.3.4 Religious affiliation

The significance of the religious affiliation was examined to determine if there were any particular groups within the Gateshead area that were more vulnerable than others. The analysis showed that the cases and controls did not differ statistically from each other. There appears to be no studies examining religious differences and incidence of failure to thrive. This is unfortunate since we cannot compare incidence rates. One problem with such studies if they were implemented would be the identification of failure to thrive would have to be standardised across the different communities. It was anticipated that there would be differences if an adequate sample of cases and controls for a selection of religions were compared. In this thesis, cases were not associated with any particular religious affiliation. This may be because there simply were no differences to be found, or because the numbers were not large enough to detect a difference. Investigating this further would require identifying failure to thrive in large populations of different religions, standardising the assessment of rate of normal growth for each population and identifying the slowest growing 10%. This is clearly beyond the scope of this thesis, but certainly worthy of further investigation, despite the scale of the task.

7.3.5 Summary

This section has examined the demographic characteristics of case and control families with reference to previous research. The differences between the data and other research findings were discussed and it became clear that often methodological or selection criteria can often account for the differences between studies. The main problem with the data used in this thesis is that it did not contain information on certain social economic factors such as location of housing, social benefits or mean income per household. Maternal psychopathology and intrafamilial relationships were not investigated either. These provide potential research areas for further investigation.

7.4 The feeding behaviour of cases and controls

This thesis analysed the feeding behaviour of cases and controls (Chapters Four and Five), to examine any differences between them that may contribute towards an explanation of failure to thrive. Two different methods were employed to study infant feeding. The first method was to investigate reported feeding behaviour. This was achieved by asking mothers to report their infants' feeding behaviours on a specially designed feeding questionnaire given to them when their infants were six weeks old (Chapter Four). The other method was to record their feeding behaviour objectively by direct observation (Chapter Five). This was achieved by analysing video tapes of sucking behaviour and measuring some other aspects of the feed (milk volume consumed and, in bottle fed infants, milk concentration).

Chapter four contained the results of the reported feeding behaviour. The six week feeding questionnaire showed a statistically significant difference between cases and controls in the mothers' rating of their infants' appetite. There was a trend in the data to suggest that cases were more likely to be fed on demand than at set times. The observational study showed that cases and controls differed in weight. This was not surprising since their weight was a criterion for their group allocation at six weeks. The sucking behaviour, mass consumed, duration of feeds, reconstitution of formula milk and analysis of the feeding diaries showed no statistically significant differences between the two groups. The implications of these findings are discussed below, firstly the results from the six week questionnaire data (Chapter Four) and secondly the objectively recorded data at follow up (Chapter Five).

7.4.1 Reported feeding behaviour

The six week questionnaire was designed to ask mothers about various types of behaviour in their infants. This thesis analysed sections A and C, which were concerned with the feeding behaviour of the infant. The questions were designed to gain information on general feeding, volume consumed/ duration of feeds, appetite, the feeding situation, oral motor problems, and body image. Each of these is an important component of failure to thrive research. The general feeding questions showed no difference in the mothers report of feed type, number of feeds per 24 hours, and whether the infant received bottled milk. A statistically significant difference was found for feeding schedule, with cases more likely to be fed on demand rather than controls. The results are discussed below in relation to previous research.

7.4.2 General feeding questions

Mothers were asked to state the feeding method they provided for their infants. All infants at six weeks of age are recommended to have solely milk based diets. The results showed that there was no difference in the feed type of cases and controls at six weeks. There is some evidence that feed type has an effect on later growth. Prolonged breast feeding may be related to failure to thrive in later infancy. In a study by Carey et al (1985) 44% of infants identified as failing to thrive between the ages of 6 and 12 months were breast fed, compared to a 16% incidence rate of breast feeding among infants that did not have poor growth. In a study by Wright et al (1994) the study of failure to thrive incidence in a community based study showed a higher than normal proportion of failure to thrive in affluent areas. The authors suggest that this may be due to prolonged feeding in affluent areas. The infants described in Chapter four were not exposed to prolonged breastfeeding by the time they were selected since they were aged approximately six weeks old.

It was found that cases are more likely to be fed on demand than on a schedule. The category of 'it depends' was excluded from the analysis. The purpose of this category is uncertain, since babies are generally fed on demand or generally at set times, and there is little use of this additional category. This suggests that cases do not appear to have developed an identifiable feeding routine unlike the control infants, whose mothers described them as being fed on a schedule. The results may be considered with the other findings from the general feeding questions. Although cases are fed on demand, the total number of feeds within a 24 hour period did not differ between the two groups. In other words the case infants are not demanding more milk or offered more milk than controls. Furthermore, it was found in other sections of the questionnaire that there was

no difference in the volume and duration of feeds and cases were described as having a poorer appetite. Despite having a poor appetite they do not consume any less milk. We must therefore anticipate what mechanisms are operating that allow cases to have slower weight gain based upon their feeding schedule and their poor appetite. The physiological consequences of being fed on a schedule as opposed to fed on demand need to be explored in more depth and are beyond the scope of this thesis.

7.4.3 Intake and duration of feeds

There is a general assumption that failure to thrive is caused by either inadequate intake or inadequate food provision (Kotelchuck, 1980, Skuse, 1985). Some research has also investigated whether increasing the caloric content consumed by case infants is a means of treating the problem (Casey et al, 1985). There have been a number of studies examining the intake of case infants. In order to collect data of this nature reported feeding behaviour provided by mothers or direct observation by measuring intake objectively has been employed. This was complemented in this thesis as both reported intake and objectively recorded intake were examined. The research regarding objectively recorded intake will be discussed in the next section in relation to the other feeding behaviour that was objectively recorded for this thesis. For the purpose of this section, the research regarding reported feeding behaviour will be examined. In terms of the volume consumed by case and control infants, research has identified some differences, though the studies are difficult to compare because the age of the infants and the method used to assess intake differs from those reported in this thesis.

In this study mothers were asked to estimate how many ounces their infant consumed of milk per feed. They were also asked to estimate the duration of the feed. For each question possible responses were provided. The answers to these questions showed no statistically significant differences between cases and controls. Reported feeding behaviour about intake has previously been collected in the form of a structured interview or feeding diary (Hepstinall et al, 1987, Ramsey et al, 1993). Ramsey et al (1993) found that abnormal feeding duration was more common in cases than controls. Abnormal feeding duration was defined as lasting from 45 minutes to two hours. Furthermore the researchers also found that infants with failure to thrive were more likely to need frequent feeding consuming 30ml of formula or less per feed. Although Ramsey et al (1993) provide some interesting results there are some factors within their design that need to be considered. Firstly, dietary intake was assessed from a structured interview with the parents and a three day feeding diary, however the infants' age ranged from one month to 42 months which makes the results difficult to interpret. Secondly there was no overall measure of daily intake. It may be that the groups did not differ in overall daily intake, but merely intake from one feed to the next. Finally the study did not provide any indication of what normal infants may consume because there was no control group. Instead the researchers compared the intake of a failure to thrive group with an organic failure to thrive group.

Hepstinall et al (1987) investigated the intake of four year old cases and controls from an inner city area. As with Ramsey et al (1993) a structured interview and three day diary formed the basis of the study, however unlike Ramsey et al (1993) these measures did not show any difference in the overall intake of the cases and controls.

Both Ramsey et al and Hepstinall et al studies are difficult to compare to the findings of this thesis. Firstly the age of the subjects is not comparable; and secondly they obtained their data through a structured interview rather than specific questions on a feeding questionnaire about the infant's feed duration and intake. Hepstinall et al (1987) and Ramsey et al (1993) also observed the infants' feeds and this data was combined with the reported feeding behaviour to estimate intake. The observational study detailed in Chapter five of this thesis contained information about the intake and duration of feeds measured by the experimenter. This will be discussed in more detail in a later section.

7.4.4 Feeding situation

A number of studies have examined the feeding situation. In particular they have examined how mothers and infants interact during feeding episodes (Drotar et al, 1990, Coolbear & Benoit, 1999; Hepstinall et al 1987; Polan et al 1991; Polan & Ward 1994; Hagekull et al 1997; Hutcheson et al, 1993). All of these studies have identified particular interactional problems by the infant and mother that differ from those exhibited by controls. However this thesis reported in Chapter four that there were no statistically significant differences between cases and controls in variables relating to the feeding situation.

Some broad methodological issues separate the previous research findings from those documented in this thesis. Firstly, the questions regarding the feeding situation in this thesis relied upon mothers reporting behaviour on a questionnaire. Mothers were asked to answer on a scale as to how stressful mealtimes were for baby and for herself. These questions are clearly not adequate enough to provide a detailed account of how mothers

judge mealtime behaviour. The questionnaire did not enable the mother to elaborate in any way as to what the source of the problem might be, for example noise or interruptions from other siblings. Another problem with the design of this research was that there was no opportunity to independently rate the interactional behaviour between mother and infant. Therefore information provided by these two questions on the six week questionnaire may be inadequate when compared to data from other studies that have either observed interactions objectively (Drotar et al, 1990; Polan & Ward, 1994; Coolbear & Benoit, 1999; Polan et al, 1991) or compared mothers' reports of feeding behaviour about the feeding situation with an observed measure by an experimenter (Hagekull et al 1997; Hepstinall et al, 1987; Hutchinson et al, 1993). Each of these studies found differences when comparing the case control families whether observed or reported, indicating the presence of more negative interactions between case infants and their mothers (Polan et al, 1991; Polan & Ward, 1994; Hepstinall et al 1987; Hutcheson et al, 1993; Coolbear & Benoit, 1999; Drotar et al, 1990). Furthermore case mothers reported that their infants were more temperamental during feeding episodes (Hutcheson et al, 1993; Hepstinall et al, 1987; Hagekull et al, 1997) and, retrospectively, that the feeding problems had been present since early infancy (Hepstinall et al, 1987).

Secondly, the objective measures used to collect data regarding the feeding environment need to be examined more closely. Previous research has found that the feeding environment was often hostile with angry interchanges between family members, or that the infant ate unsupervised (Hepstinall et al, 1987). The infant can often be very temperamental during mealtimes as a means of trying to take control over a stressful feeding environment. In extreme cases these kind of negative interactions can contribute to the development of infantile anorexia (Chatoor et al, 1997). The feeding

environment has been described as noisy (Skuse, 1989); or the environment becomes increasingly stressful for the mother because the infant is highly distractible (Wolfe & Glass, 1992). Hepstinall et al (1987) found that mothers of cases became increasingly frustrated by their infant's behaviour and often resorted to persuasion techniques. These studies were conducted using observational techniques in which a series of mealtimes are recorded on video and later played back and assessed. So they do not really provide data comparable to the data reported here in this thesis. The data in this thesis was based upon the reports of case and control mothers. This thesis found no statistically significant difference between cases and controls when mothers were asked about the feeding situation.

A third problem with some of these studies is that they have selected referred case infants which do not give us a representative idea of how infants who fail to thrive behave. Also infants have been of different ages, for example eight months to 26 months (Hutcheson et al, 1993) ten months to two years (Hagekull et al, 1997) and six months to 36 months (Polan et al, 1991). They do not show what the feeding situation was like in early infancy, prior to the onset of weaning. This is one of the strengths of this thesis that early feeding behaviour was investigated. However since these studies have included structured questionnaires or interviews aimed to collect reports of interactional behaviours this thesis is arguably in a weaker position. For example Hepstinall et al (1987) used a structured interview to obtain information about the infant's temperament during feeding episodes. However in response to this there was data available from a section on the feeding questionnaire used in this thesis designed to collect information about how well the infant coped with various daily routines for example bathing and dressing. This section was designed to provide some indication of

the infants' temperament. However the analysis of this section was beyond the scope of this thesis but may have indicated case control differences.

An interesting point is that not all research has found evidence of problems within the feeding context. Gremese et al (1998) found that mothers reported no specific feeding problems, so it is not unusual to find that cases and controls do not exhibit mealtime behaviour that is significantly different from one another. Finally a study of temperament and weight gain was investigated by Carey (1985). The subjects were taken from two extremes of a population of infants aged between six and twelve months. The fastest growing 10% were compared with the slowest growing 10%. A temperament questionnaire was completed and the infants weighed every two months between the ages of six and twelve months. Carey found that the infants who gained the most weight between the ages of six and twelve months were described by their mothers as being temperamental. However mothers of the slowest growing 10% were not described as any different temperamentally. Carey concluded that more fussy or picky infants were probably fed more frequently as a means of mothers coping with their difficult behaviour, thus enabling them to gain weight at a faster rate than slower growing infants. Although failure to thrive infants were not the focus of Carey's study, it does suggest that mothers of infants do not always report problems when their infants have slow growth. Another feature was that Carey took two extremes of a population and this is not representative of the whole population. This thesis reported a community based study whereby the slowest growing 10% were compared with a random selection of the remaining 90% of the population. Also all infants were selected from an entire community and not restricted to poorer families. In sum this study could have employed a more structured questionnaire examining the feeding situation and an observational technique in line with previous research. However if any differences had

been observed its comparability with other research is debatable considering the early age of the infants investigated in this study (i.e. eight to twelve weeks) and because the study was community based and not centred around referred cases.

7.4.5 Oral motor problems and the regulation of intake

This thesis also found that there was no statistically significant difference in the reported oral motor problems or the regulation of intake. Oral motor problems were recorded by asking mothers to assess their infants' sucking and swallowing, while regulation of intake concerned possetting and vomiting. This is an interesting finding because previous research points to some frequency of oral motor problems in failure to thrive infants. An inability to coordinate sucking, swallowing and breathing can result in digestive/absorption problems and consequently inadequate intake. Oral motor problems can range from excessive drooling, dysfunctional sucking, swallowing and breathing, to tongue thrusting, biting and intolerance to certain food textures (Lewis, 1982). Some studies have found that oral motor problems are more frequent in cases than controls (Dahl, 1987a; 1987b; Mathisen et al, 1989; Reilly et al, 1999). Some research suggests that oral motor problems are provoked by the late introduction of solid food, suggesting that there is a critical period when solids must be introduced if they are to be tolerated by the infant (Illingworth & Lister, 1964). The reason for the late introduction of solids may be prolonged breast feeding (Casey et al, 1984). However there are problems comparing the results documented in this thesis with previous research findings. Firstly, the study of oral motor problems is usually conducted on weaned infants. In Dahl's study (1987a, 1987b) the age of the infants was 3 to 11.8 months (1987a) and the infants were followed up at 2 years of age (1987b); in

Mathisen et al (1989) the mean age was 11.9 months; and finally for Reilly et al (1999) the mean age was 14.6 months. In this thesis the age of the infants was approximately six weeks, when the questionnaire was completed by the infant's mother. The infants were therefore younger and exposed to a different feed type. Finally these studies employed observational methods to examine the oral motor problems of infants, whereas the investigation described here did not. The method used here to assess oral motor problems were specific feeding questions on a questionnaire. The follow up study did not have the means to collect data on drooling, dribbling etc. These problems, if they were present at all, may have been evident in longer pause lengths between sucks, as the infant swallowed the milk. No differences in the sucking behaviour of cases and controls were observed in the follow up study; this will be discussed in a later section.

7.4.6 Body image

The questions regarding body image asked mothers to assess their infant's size by describing them as either very chubby, chubby, average, then or very thin. The reason for asking mothers this was simple: to find out if case mothers would assess their infants differently from control mothers. There were no statistically significant differences between cases and controls; most mothers described their infant as average or chubby. The use of terminology for the response categories needs to be addressed. The term 'chubby' may have certain connotations and is not the most appropriate means of classifying infants body image. It is suggested that the use of language for this issue regarding body image needs to be carefully considered in future research.

There is evidence to suggest that an infant's weight is associated with maternal decisions made about food (Stordy et al, 1995; Stein et al, 1994; Morgan et al, 1995). The implications of this research may have implications for failure to thrive research. Firstly, if mothers of failure to thrive children judged their infants to be chubby, it may imply that they were limiting their infant's intake as a means of controlling their weight. There is evidence that suggests that mothers attitudes over what constitutes a healthy diet can affect their child's nutritional intake. For example Morgan et al (1995) found that regardless of socio-economic group and maternal education, mothers described a high fibre low fat diet as appropriate for infants. Attitudes of this kind can affect the diet infants are exposed to. In a study by Stordy et al (1995) the content of home prepared weaning foods were analysed for content. The study showed that they were low in energy, protein, fat and key minerals but high in carbohydrates and sodium. Therefore a mother's perception over what constitutes a healthy diet for infants affects the type of food an infant is exposed to. In extreme cases a study of mothers with eating disorders and their infants showed that there were more negative interactions during feeding episodes in the infant and the infants were lighter than controls (Stein et al, 1994).

7.4.7 Appetite

Mothers of cases described their infants as having poorer appetite than mothers of controls. This has been found in other research. For example, Wolfe and Glass (1992) found that not only was the appetite of case infants described as poorer, but cases were also described as being highly distractible. In extreme cases and infants with failure to thrive refuse to eat by Chatoor et al (1997). Ramsey et al (1993) found that case infants

do not appear to demand food and have little or no interest in it. The infants in the Ramsey et al study were approximately 24 months whereas the infants in this study were six weeks, therefore poor appetite seems to be common among infants with failure to thrive regardless of their age. It is not an unreasonable conclusion that infants who are failing to thrive have poorer appetite, however the reasons why they have poorer appetite is unclear and would need investigating. The reasons for poor appetite may be explained by Chatoor et al (1997) who describe the origins of infantile anorexia. A series of stressful feeding interactions can lead for a struggle for control between the infant and the caregiver. Alternatively there could be a physical reason for a reduced appetite. Carey and McDevitt (1978) found that infants who are failing to thrive have a low threshold for stimulation, and Chatoor et al (1997) suggested that because infants who are failing to thrive tend to be easily distractible that they have reduced awareness of their physiological needs. From the research mentioned above, appetite and temperament appear to be related. Unfortunately temperament was not investigated in this thesis.

Not all previous studies into failure to thrive have found differences in their feeding behaviour. Gremese et al found that mothers of failure to thrive infants did not report them as having abnormal feeding behaviours such as bottle refusal and poor sucking. The poor growth of the infants was attributed to inadequate energy intake and psychosocial problems. It is unclear from the paper whether the inadequate intake was reported by mothers or merely inferred by the clinic from which they were recruited. In relation to the findings of this thesis there were no differences between cases and controls regarding oral motor problems or milk intake. The only differences were 'appetite' and 'feeding schedule'.

We must now consider why the reported behaviours were not significantly related to failure to thrive as previous research as might have suggested. It may be the case that there is no detectable difference in the feeding behaviour of case and control feeding behaviour at six weeks of age. Other stressful factors may become evident in later infancy leading the mother to become more frustrated and report problems that may have been present in early infancy but she was more able to cope with them. The infants in this thesis were identified at six weeks, the time at which the feeding questionnaire was completed. It is possible that it was too early for mothers to detect any specific behavioural problems during feeds. Another problem is that when a mother is made aware that her infant has poor weight gain i.e. by their doctor or health visitor, it is possible that she will become more sensitive to her infant's behaviour. This may lead to the mother expecting the infant to behave in a certain way that would account for their poor weight gain. In sum, perhaps the problems are not acute enough for a mother to identify at six weeks.

Another possibility is that there are no behavioural difference between cases and controls. Perhaps behavioural problems specifically related to feeding only manifest themselves in late infancy, when the infant begins to respond more actively to the environment around them.

Secondly mothers may have accounted for their infants' behaviour by reference to their temperament i.e. 'he is fussy/grumpy' rather than 'he is a difficult feeder'. It may be the case that mothers of failure to thrive infants described their infants less favourably in terms of temperament, but not necessarily their feeding behaviour. There is research available that shows that mothers of failure to thrive infants do describe their infants' temperament less favourably than controls, however, they also report feeding problems,

for example Chatoor et al (1997). It should be pointed out that the children in the Chatoor study were older i.e. weaned and had been failing to thrive for longer than the infants described in this thesis.

Failure to thrive research investigating feeding behaviour needs to take into consideration that information received from mothers is partly a reflection of the mothers' own expectations. Through the mother's expectations the infant's behaviour may be altered through a series of poor interactions which can prolong a feeding disorder. This was evident in the study of infantile anorexia by Chatoor et al (1997). Chatoor describes a model by which she argues that feeding disorders develop. This involves a series of poor interactions between mother and infant as each struggle for control during mealtimes. Whether the initial problem lies with the infant, as a temperament problem, or with some mismanagement by the mother, or both can only be speculated upon. What Chatoor et al (1997) does suggest is that these poor interactions prolong feeding disorders in infancy.

Finally the data are from self reports in which questions may not have been answered honestly. Since mothers were asked to complete and return a questionnaire it may have resulted in mothers responding inaccurately about their infants' behaviour. It was mentioned earlier how some studies used face to face interviews with parents to collect information about the infants, for example Hepstinall et al (1987). Face to face interviews may be a better approach for collecting data of this kind.

7.4.8 Objectively recorded feeding behaviour

It was anticipated that there would be evidence of feeding differences between cases and controls. There are many different techniques that can be used to study infant feeding. Feeding behaviour may be recorded directly or it can be reported. The previous section focussed on reported feeding behaviour. There many different ways of recording infant feeding. Chapter One described different techniques for studying infant feeding behaviour. The methods used for studying milk feeds are different to those for solid foods. The various methods available for studying infant sucking directly include using transducers (Field et al, 1982; Berbaum et al, 1983; McGowan et al, 1991) or a strain guage (DeMonterice et al, 1992) or ultrasound techniques (Bu'lock et al, 1990). Alternatively, to assess an infant's consumption of solid food there are the Neonatal Oral Motor Assessment Scale (Palmer et al, 1993) or the Schedule for Oral Motor Assessment (Reilly et al, 1999).

7.4.9 Sucking behaviour

For the purpose of this thesis, milk feeds were recorded and analysed. The method required taking video recordings of feeds, coding them using a dedicated computer program (Minkey) and analyse using a mixture model Chetwynd et al (1998). This procedure was used because it is the least obtrusive of the other methods, it is designed to record and analyse milk feeds and it has been shown to be a valid and reliable method (Woolridge & Drewett, 1986; Drewett & Woolridge, 1972; Bowen-Jones et al, 1982).

The observational study described in this thesis was designed to objectively record milk feeding behaviour in case and control infants. Two consecutive feeds were recorded and analysed for differences by an experimenter unaware of the group of the infants. This would strengthen confidence in any differences found between the case and control feeding behaviour, since the experimenter would not be biased in their judgements. Chapter Five contains the results of the observational study. The objectively recorded feeding behaviour was collected when the infants were aged between eight and twelve weeks. A number of measures were taken including the video recordings of the infants' sucking during feeds. The experimenter recorded two consecutive milk feeds and analysed the data (Chapter Five). The sucking behaviour of cases and controls was condensed into a series of sucking parameters and these were initially compared using Mann-Whitney U tests. The results were statistically non significant (Chapter Five). This means that at the time of follow up the sucking behaviour of cases and controls did not differ from each other.

Research has found that infants who fail to thrive have oral motor problems (Reilly et al, 1999). It is difficult to compare the findings of this study with those reported in this thesis because the infants were older (12-17 months) and using a different feed type (solid food). Another factor that makes studies of oral motor dysfunction difficult to compare with the findings of this study is the nature of the measurements made. In this thesis the sucking behaviour of infants was characterised by a series of sucking parameters that described the behaviour during the duration of feeds. There was no sucking parameter available for behaviours such as choking, possetting, dribbling etc. Although these behaviours may have been visible on the video tapes, these behaviours were not coded. In the studies of oral motor dysfunction the frequency of such behaviours is recorded on a checklist by the experimenter. Therefore we cannot make a

comparison between frequency of oral motor problems in the milk feeds of infants in this study and the solid feeds of infants in the other studies. The only sucking parameter that may be used as an indication of any potential problems was the mean pause length at the start of the feed and the end of the feed. If cases had been found to have an increased pause length between bursts of sucking when compared to controls, it would have suggested that there was some sort of feeding problem that was initiating longer pause length. However, there was no difference between cases and controls on any of the sucking parameters, indicating that there was no behavioural differences between cases and controls. Furthermore in the above mentioned studies of oral motor dysfunction there is no indication given at which point these infants began to fail to thrive. If these infants only failed to thrive once solid food was introduced at four months and their growth was reasonable before this point, the research does not tell us anything about early milk feeding behaviour and its relationship with failure to thrive in later infancy. In this thesis it is quite clear that the infants began to fail to thrive by six weeks of age. If further investigation had been carried out examining the feeding behaviour of weaned cases and controls, this would have given a more developmental perspective of how the feeding behaviour of cases identified at an early age mature when other food types are introduced.

7.4.10 Feed type

The observational study found that there was no statistically significant difference in the feed type of case and control infants, i.e. there was no evidence to suggest that case infants were more likely to be bottle fed or breast fed. This is surprising since there is so much evidence that breast milk provides a variety of immunological and

psychological benefits (Goldman et al, 1986). Therefore it might be anticipated that there would be a higher incidence of bottle fed infants in the case group than the controls. Formula milk models breast milk but it does not contain the components responsible for its hormonal or immunological benefits. Despite the benefits of breast milk, there is research to suggest that prolonged breast feeding is associated with slower weight gain (Wright et al, 1994). This thesis suggested that feed type has not had an effect on weight from birth to the observational study; any benefits from consuming breast milk instead of formula have not manifested themselves in terms of weight gain.

7.4.11 Intake and duration of feeds

The observational study showed that mean mass of milk consumed for the two recorded feeds and the mean duration of the two feeds were no statistically significant different in cases and controls. This is another interesting finding, since it would appear reasonable to assume that this is a key factor in which the infants would differ. Some differences have been reported by previous research. Gremese et al (1988) investigated three groups of infants, controls, infants with failure to thrive and infants with failure to imbibe. It was reported that the volume consumed at feeds by cases (mean = 130 ml) is less than controls (mean = 165 ml) and took longer to feed (mean = 15 minutes) than controls (mean = 11 minutes) (Gremese et al, 1998). Findings such as these clearly suggest that failure to thrive is due to poor intake. The research suggested that infants with failure to thrive do not consume enough to gain weight adequately. The theory of inadequate intake or inadequate food provision resulting in poor growth is strengthened by other research. Schaffer-Bell and Woolston (1984) measured weight and intake per kg of weight in infants with organic and non organic failure to thrive. The absence of a

control group makes the results difficult to interpret. Energy intake during hospitalisation was greater for the organic than the non organic group. The infants ranged in age from 3.5 to 26 months for the organic group (n=21) and 3.5 to 28 months for the non organic group (n=9), another factor that makes the results difficult to interpret. Intake will be related to age, and the variation in age within the groups makes it difficult to gain an understanding of how the infants feed.

As previously mentioned earlier in the discussion, Ramsey et al (1993) examined intake in infants with organic failure to thrive and non organic failure to thrive. The results are difficult to interpret because there was no control group and the infants ranged in age from one month to 42 months. Although Ramsey et al found group differences the observed feeding behaviour component of their research may be considered much weaker than that reported in this thesis. The observed feeding behaviour took place in a laboratory environment and not in the infant's home. The feed was observed through a glass panel and the entire feed was not observed, but a period of between 15 and 20 minutes of the feed was observed. This thesis has a number of strengths over this study. Firstly a control group was used, two consecutive feeds were observed in the infant's home environment and the intake and duration were carefully recorded.

There is research to suggest that the intake of cases and controls does not differ. Hepstinall et al (1987) found no difference in the quantity consumed by cases and controls or the duration of meals. An earlier section (7.4.3) that described the reported feeding behaviour of cases and controls discussed two studies that investigated food intake in failure to thrive. These two studies were Hepstinall et al (1987) and Ramsey et al (1993). Both studies investigated reported and observed feeding behaviour in infants with failure to thrive. Hepstinall et al found no difference in the gross intake of the case

and control children. However the researchers found that control infants consumed slightly more energy per day (1424Kcal) than to cases (1388Kcal) though the difference was not statistically significant. However if energy intake per unit of body weight was calculated the case group intake was higher than that of the controls (100 Kcal compared to 91 Kcal). This difference was statistically significant. The authors suggest that the difference may be explained by the fact that case infants have a higher proportion of lean body mass than control infants in relation to total body weight.

Hepstinall et al suggested that certain familial interactions were more likely to be associated with case families than the control families during meal times. However, although more frequent in case families, there was no explanation as to how these characteristics translated into oral motor problems. This thesis did not find any differences in intake or feed duration between cases and controls. One possibility is that more feeds should have been recorded perhaps over a whole 24 hour period, but this would have made the study more intrusive and would have been impossible in practice.

The findings of this thesis suggest that cases are consuming the same amount as controls, but there is the question as to whether the energy content of the meals is the same for cases and controls. There are studies that show that infants and children are good at regulating their energy through the day. For example in a study of children's intake aged two to five years showed that for individual meals the within subject intake of children differed, however if the energy intake across the day was examined, it was quite consistent (Birch et al, 1991). Similarly a study of complementary feeds given to milk fed infants showed that the infants adjusted their milk intake to allow for the presence or absence of the complementary feeds (Drewett et al, 1987). Finally the intake of one year old children was found to vary from one meal to the next, the

implication being that feeding measures taken from single feeds do not provide a reliable account of children's feeding characteristics (Young & Drewett, 2000). These studies indicate that if children's feeding behaviour varies from one meal to the next, studies that investigate one or two feeds may not provide an accurate representation of feeding behaviour. If this were the case, previous studies of failure to thrive infants that objectively study only a single feed of an infant might not gain representative results regarding the infant's daily intake and feeding behaviour. Ramsey et al (1993) studied a single feed of cases within a laboratory rather than the infant's own home. The feed was observed for a period of 15 to 20 minutes rather than examining the whole feed. This is clearly an inadequate procedure when the above research about the variability of intake is taken into consideration. This thesis studied two consecutive feeds in case and control infants that took place during the day and in the infant's own home. No difference was observed between cases and controls. This finding was complemented by Hepstinall et al (1987) who also examined two feeds in cases and controls and found no difference in the global intake of cases and controls.

Collectively the studies of Birch et al (1991), Drewett et al (1987) and Young and Drewett (2000) suggest that if infants who fail to thrive were not receiving enough milk at a given feed they would compensate by consuming more at a subsequent feed. However the children and infants mentioned in these studies (Birch et al, 1991; Drewett et al, 1987; Young & Drewett, 2000) were all normally growing infants with no growth problems. Taking this research into account we can only speculate as to why the case infants consumed the same amount as controls in the study reported here. It may be the case that the case infants were poorer at absorbing the adequate nutrients from the milk provided. However, if there was a digestive problem the infant may have a higher frequency of vomiting or possetting. There was no significant difference in the

frequency of such problems in the questionnaires given to mothers when the infants were six weeks of age. However, inadequate intake has been associated with many different factors including poor feeding interactions between mother and infant (Rathburn & Peterson, 1987) infant temperament and maternal sensitivity (Hagekull, Bohlin & Rydell, 1997) none of these were measured in this thesis.

A reasonable conclusion is that the case and control infants did not differ on their global intake as Hepstinall et al (1987) found in their study. Perhaps there is some other explanation. The family characteristics that were measured were found not significantly different in cases and controls, so unlike Hepstinall et al (1987) this thesis did not have an immediate alternative variable for which cases and controls differed. Some other explanation is needed. For instance, if an infant has an infection or a respiratory problem, its metabolic or digestive system will be affected. If case infants are more prone to reoccurring infections their digestive system will alter, perhaps leading to poor absorption of key nutrients. It would be useful to measure the frequency of illness in early life would be useful to measure, to determine whether reoccurring infections were associated with poor weight gain.

Finally it is necessary to consider the relationship between intake and weight. Intake can be measured in terms of volume as it was in the study within this thesis, or it can be measured as energy intake. There is evidence to suggest that the relationship between weight and energy intake varies according to the age of the infant. The power of the relationship between these two variables decreases up to first six months of life and then increases thereafter (Drewett & Amatayakul, 1999). The research suggests that for the first six months of life the adiposity of the infant changes. Fat which is metabolically inactive is gradually replaced with lean mass that is metabolically active. The

implications for this type of research and the research investigating intake in cases and controls is very important. It suggests that in order to study the intake of cases and controls the weight of both lean and fat mass should be measured. It is the relationship between these and energy intake that should be studied. Finally the relationship between energy intake and weight changes with the age of the infant should also be taken into consideration. Therefore the sample of infants used in studies of this nature should be similar with a small age range.

7.4.12 Formula concentration

Since there were no statistically significant differences between cases and controls in sucking behaviour, mass consumed and duration of feeds, there was the possibility that the concentration of the formula milk may be a source of poor growth. Of course this theory could only be considered regarding formula fed infants, since breast milk samples were not taken. A sample of the formula milk was taken prior to each feed and the dried matter content (i.e. the formula milk powder) was analysed to determine whether failure to thrive infants were receiving over diluted formula. If formula milk is over diluted, the infant would not receive the correct nutrients and would not grow normally. Fat is very important to growth. For the first six months of life fat accounts for 35% of the infant's weight gain (Fomon et al, 1982). If the formula milk were diluted over a sustained period the infant would be unable to gain weight because of reduced fat intake. Potur and Kalmaz (1996) found that infants that were fed by incorrectly prepared formula were significantly lighter in weight than breast fed infants. Egemen et al (2002) also suggested that incorrectly prepared formula could have serious physiological implications. Over diluted formula could lead to protein energy

malnutrition, while over concentration could lead to hypernatremic dehydration or obesity. There have been no studies of whether mothers of infants who fail to thrive incorrectly prepare their infants formula milk.

The analysis of the dried matter content of the formula milk samples showed that mothers are consistent in their preparation of formula milk across feeds, but there was no statistically significant difference in the preparation of formula milk between cases and controls. This means that for the two feeds that were objectively recorded, the preparation of formula milk did not differ. However there were a number of breast fed infants that failed to thrive. If the formula milk of case infants had been found to be over diluted then we could have concluded that poor growth was due to inadequate milk provision. However, as described above there is the possibility that the infant would simply consume more milk in order to compensate for the inadequate energy intake. The cases were more likely to be fed on demand but their volume intake and the number of feeds within a 24 hour period did not differ from controls.

Since there was no statistically significant difference between cases and controls on the behaviours measured in the observational study, there is the possibility that the reason for poor growth may lie elsewhere. One reason that may explain these results is that the experimenter observed only two consecutive feeds, within twenty four hours when many other feeds would have taken place. If all feeds within the twenty four hour period could have been recorded and analysed, there may have been statistically significant differences between cases and controls. While observing feeds for a twenty four hour period is an ideal, this would result in fewer participants, since the study would become more intrusive.

7.4.13 Objectively recorded and reported behaviour

This leads to an important question about whether or not the objectively recorded behaviour at follow up was representative of the infants general feeding behaviour. One way to examine this was to compare the mothers' reports with that objectively recorded by the experimenter. During the follow up study the mother provides a source of information about how her infant feeds. The mother interacts with her infant throughout the day and can detect any behavioural changes. If she has previous children, she may compare the feeding pattern of her infant with that of previous children in order to make a judgement about how effectively they are feeding. Asking the mothers to complete a feeding diary 48 hours prior to the experimenter recording the feeds was one way of monitoring how the infant was feeding. There were no statistically significant differences between cases and controls in the mean number of feeds per day, the estimated duration of feeds, the estimated volume consumed (bottle feeders) or the average number of problems reported during feeds. This is valuable evidence that there are indeed no differences between cases and controls on these variables as described by the mother. This also reinforces the finding objectively recorded i.e. there were no differences in the intake or duration of feeds.

7.4.14 Summary

In this thesis, the evidence found regarding the feeding behaviour of infants suggests that there is no difference in the sucking behaviour of these infants. There is no difference in the amount of milk consumed or the duration of feeds – whether reported

by the mothers or recorded objectively by the experimenter. The only difference that can be identified is the mothers' description of their appetite, with mothers of cases reporting poorer appetite than controls. It would be interesting to see if these descriptions of appetite continue into later infancy, and whether more problems become identified during feeding episodes at a later stage.

7.5 Growth over the first year and the influence of feeding behaviour on weight gain

The growth of cases and controls was monitored from birth to the end of the first year. Chapter six presented the data for cases and controls according to sex. The Thrive Index was used to identify infants with poor weight gain from birth to six weeks. Chapter Six reported that 27% of cases identified at six weeks had sustained poor growth at twelve months. Although this is not as high as we might have anticipated, it is still reasonable. Poor growth can be identified very early in infancy and just over one quarter of infants identified with poor growth continued to show poor growth over the first year.

Some growth variations in the study sample was anticipated. Regression to the mean is the term given to the apparent upward trend in weight gain of small infants and the apparent downward trend in weight of large infants relative to the population. Oscillations in growth in the first year are very common (Giani et al, 1996). The implications for this thesis is that 73% of case infants identified at six weeks were no longer identified as having poor growth at the end of the first year due to the natural variation in growth patterns observed in early infancy. Despite the recovery of these

infants it would be useful to monitor their growth in the long term, since it may be the case that some of these 73% of infants may have reoccurring failure to thrive (Edwards et al, 1994) in later infancy.

The second regression analysis detailed in chapter six investigated whether a variety of variables recorded in early infancy might predict weight from birth to twelve months. An infant's growth may be related to their feed type (Wright et al, 1994; Casey et al 1984) or their feeding behaviour (Agras et al, 1987). The rationale for the regression analysis was to examine whether these early feeding behaviours might predict weight at the end of the first year. The feeding variables were of particular interest, since the infant's growth depends upon their feeding behaviour. The feeding variables were feed type, mean mass consumed, mean duration of feeds and the sucking parameter estimates. These variables together with birth weight, sex and age were used to predict weight at the end of the first year.

The regression analysis showed that sex and the suck duration at the end of the feed were the only statistically significant variables. Females were 516g lighter than males at the end of the first year. None of the remaining variables predicted weight at the end of the first year. It did not matter how the infant was fed (i.e. breast or bottle); how much the infant consumed; or how long they fed for as recorded in the observational study. This is surprising because it would be reasonable to assume that weight gain was related to intake. There could be two possible explanations for this finding. Firstly, there is the possibility that monitoring intake and duration of feeds for just two feeds during the observational study did not provide enough for understanding how these infants feed. If more feeds had been recorded at follow up for instance during a 24 hour period, perhaps these variables might have predicted weight at the end of the first year.

Secondly, it needs to be pointed out that feed type, intake and duration of feeds in early infancy would naturally change during the course of the first year of life. Infants are usually weaned at four months. When infants are weaned their intake and duration of feeds changes. Investigating feeding behaviour past eight to twelve weeks of age was beyond the scope of this thesis. It could be anticipated that the type of solids, intake and duration of feeds might have been a predictor of weight gain to the end of the first year, since infants would have been exposed to solids for longer during their first year (i.e. eight months) than they had been to an exclusively milk diet (four months).

A final note about the weight of the infants in the cohort is that we can expect a certain amount of growth fluctuation during the first year (Berkey et al, 1983). If weight fluctuates so much in the infants, then the power of predicting weight based upon a few feeding variables taken in early infancy is reduced. According to Berkey et al's (1983) description of growth, the ability to predict weight from measures taken in early infancy is likely to be unsuccessful.

Previous research has shown that vigorous feeding styles predict adiposity at two years of age (Agras et al, 1987) and at six years of age in the same cohort (Agras et al, 1989). Agras et al defined a vigorous feeding style as high sucking pressure, long sucking bursts, long suck durations, shorter intervals between sucks and fewer but larger feeds. This thesis did not find any results that could support this finding. The method adopted by Agras et al 1989 was taken from Kron et al (1968). The sucking behaviours were measured using a transducer and the sucking pressure, sucking bursts, suck durations, inter suck intervals and volume consumed were calculated by averaging the infant's behaviour across the whole feed. This method adopted by Agras et al (1989) differed from the method used in this thesis. The method used to analyse sucking in this thesis

characterised sucking at the start of the feed and at the end of the feed, whereas Agras et al did not separate the beginning and end of the feeding episode.

However, there are some similarities between the results of Agras et al's study and these reported here. For example, Agras et al found that increased suck durations across the entire feed were associated with greater weight gain. In this thesis there was clearly a trend in the data to suggest that for every s increase in suck duration at the end of the feed was associated with a decrease in weight of 608g in the infant (Table 6.3b). This is similar to what Agras discovered, but it can be explained by a difference in the method used to record the behaviour and the analysis of the behaviour recorded. Agras' finding that shorter intervals between sucks was associated with heavier infants is also of particular interest. This thesis found a trend in the data to suggest that for every s increase in the pause length at the start of the feed was associated with 307g decrease in weight. Unfortunately the results of the regression analysis were not significant when the remaining sucking parameters were taken into account. If the results had of been statistically significant, it would have suggested that for every second increase of pause length at the start of the feed was associated with lighter infants at the end of the first year. Again, this would have been the inverse of what Agras found and would certainly provide more evidence suggesting that the way an infant sucks predicts the weight gain long term. Agras et al studied vigorous feeding as an indicator of obesity, using a long term follow up study. Their research suggested that sucking behaviour, although replaced by solids and other oral behaviours, is a predictor of weight gain. This means that the infant continues to feed in a similar way once solids are introduced. This thesis did not measure weaning behaviour, so there is no way of determining how lighter infants feed on solids and how this is comparable with their sucking behaviour. But there is the possibility, suggested by Agras work that the sucking behaviour transfers

onto the introduction of solids, and that in infants who suck strongly continue to feed strongly and have above average weight gain.

It could be implied that the vigorous feeding style is evidence of a hungrier baby. The inverse could be said about the sucking behaviour of case infants in this study. The six week feeding questionnaire showed that mothers of cases and controls described no difference in the sucking behaviour of their infants. The mothers did describe a difference in the appetite of their infants. Mothers of cases reported that their infants had poorer appetite than mothers of controls. This suggests that cases are less hungry than controls which again, would relate to Agras' work.

7.6 General themes

The purpose of this section is to bring together some of the reoccurring themes that have been discussed in relation to the individual findings in this thesis. This thesis had four aims and has achieved each of them. Failure to thrive cases and controls identified in early infancy using an appropriate method (Thrive Index). Feeding behaviour was measured using two separate procedures, a questionnaire and a observational method. Finally, the growth of these infants was monitored for one year. Few statistically significant differences were found between cases and controls. Throughout the discussion so far, it has been shown that there is a lot of contradictory evidence in the area of failure to thrive research. This appears to be due to the way in which cases and controls are selected and different design characteristics within the research area.

7.6.1 Sampling techniques

Identifying a sample of cases will depend upon how poor growth is defined. The introduction considered the different perspectives on how poor growth has been identified and the superiority of using the Thrive Index. It is not the purpose of this section to reiterate this, but to focus upon sampling techniques. There have been some studies conducted that used a group of referred/hospitalised case infants (Kotelchuck & Newberger, 1983; Bithoney & Newberger, 1987; Casey et al, 1984; Strum & Drotar, 1991, Puglieses et al, 1987) and some have no control group (Schaffer-Bell & Woolston, 1985; Ramsey et al, 1993). Other research has examined failure to thrive in low income based families (Altemeier et al, 1984; Crittenden, 1987; Black & Krishnakumar, 1999) while others have focussed upon maternal psychopathology as a means of selecting families for research (Aurelius et al, 1987; Stein et al, 1994).

There have been a number of studies that have examined the social and familial characteristics of families with referred cases of failure to thrive (Kotelchuck and Newberger, 1983, Casey et al, 1984, Bithoney and Newberger, 1987, Black and Krishnakumar, 1999). All of these studies matched cases with control subjects in terms of age, sex, race and family income. The problem is that upon closer examination of the study sample, the majority of subjects in both the case and control groups originate from the lower income families. This suggests two possibilities about the incidence of failure to thrive. Firstly that there is a higher incidence of failure to thrive in lower income families, however without community based study evidence this cannot be accepted as a suitable line of argument. Secondly, it may be the case that lower income families are more likely to be referred to hospital for failure to thrive than more affluent families.

Research of this nature can be considered as clinical case studies. This is because the research has investigated failure to thrive within a specially selected population, rather than across the whole population. While case studies provide us with a valuable insight into the nature of failure to thrive within a specific sample, they do not further the understanding of the origins of a condition. Hospitalised infants are not representative of the whole failure to thrive population. For example, there could be suspected abuse or neglect that has resulted in the infant being hospitalised. Clearly health professionals perceive the nature of failure to thrive differently from parents. If an organic cause cannot be found for poor growth the clinician will consider psychosocial factors. Parents on the other hand may view the situation differently, attributing the poor growth to a virus or temperament rather than the home environment (Strum & Drotar, 1991). Referred cases do not give us a representative sample of failure to thrive.

Social class is often used as selection criteria for a number of different studies that have investigated failure to thrive. For example Crittenden (1987) selected families from low income backgrounds in Virginia. The study found that intrafamilial relationships were often more stressful in the case families than the families that had adequate parental care. In another study by Altemeier et al (1984) a sample of low income families was studied and a sub sample of case infants was compared with control infants. Studies such as these are searching for additional associations within failure to thrive that originates in deprived families. A more appropriate design would be to look for the frequency of familial characteristics across all sections of a whole community. Furthermore, these studies are just a few of those that suggest that if cases and controls are matched on social economic factors, the incidence of failure to thrive is associated with factors such as interpersonal relationships within the family. However since they

do not taking the wider community into account it may be that the results cannot be treated as representative of the wider population.

It could be argued that community based studies including all social classes rather than just hospital based studies provide more understanding about the aetiology of failure to thrive (Wright et al, 1994; Willensky et al, 1996) and give a more representative insight into factors associated with failure to thrive. However community based studies are rare and unless more studies are conducted our understanding of failure to thrive will be limited. This could affect the care of case infants in the long term. For example if research continues to investigate infants with failure to thrive from clinics or low income families while more affluent families may not receive specialised care.

This thesis addressed all of these important key issues regarding sample selection. The questionnaire data were taken from a community based study of feeding and growth. All social classes were invited to participate and cases and controls were selected at six weeks using Thrive Index principles.

7.6.2 Methodological issues

The second major reoccurring theme in this discussion has been methodological issues regarding the research reported here and previous research. There are issues over the number of subjects used to compare cases and controls and the number of groups compared. For example should a study merely compare cases and controls, or should there be additional groups studied such as organic failure to thrive infants and perhaps infants from homes recognised as at risk from substance addiction or physical

abuse/neglect? In order to answer this we would have to consider the relative advantages of studying other groups. For example studying a group of non organic failure to thrive and a group of controls can tell us if there are any differences between these two groups. However, would it be more valuable to include a group of organic failure to thrive infants as an additional comparison group? Studying additional groups can provide more insight into the nature of failure to thrive. For example Crittenden (1987) studied a number of different groups including failure to thrive and a control group. This study demonstrated two things. Firstly that failure to thrive can occur in families without physical abuse and neglect. Secondly, failure to thrive can be placed within some sort of wider perspective that has investigated the similarities and differences between case infants and infants from homes with additional problems. Other research has studied organic and non organic failure to thrive in the absence of a control group (Ramsey et al, 1993). While studies such as this provide a comparison between infants with a physical reason for poor growth and those without, by failing to investigate a control group there is no indication how they differ from normal infants.

One problem that may be encountered by studying additional groups is that the sample size will decrease. In Crittenden's (1987) study 19 case infants were compared with 21 controls, 15 infants from abusive homes and 17 from neglectful homes. In one particular study there were 15 cases compared with 86 controls (Altemeier et al, 1985). Why there were so many controls included in this study is unclear. Large sample sizes can also be problematic. One problem is that you need to control for individual differences within the group. For example, if we examine all infants with poor growth, we could potentially have a large subject sample. However, we would have to control for premature infants, or organic reasons for poor growth (e.g. cerebral palsy) etc. If these factors were not taken into account there would be different reasons for the rate of

growth in the study sample. In a particular study by Polan et al (1991) birth weight and gestational age were not taken into account within the case sample. The researchers included infants born at thirty five weeks or more within the case sample. Including infants that are not full term may have affected the results since preterm infants are smaller and lighter. Once a set of inclusion criteria has been carefully established, the number of subjects available for research can quickly diminish. For example Reilly et al (1999) initially had a sample of 2510 infants. Once the inclusion criteria and attrition factors had been taken into account, only 47 case infants were identified and subsequently studied.

Another problem within research is the age range of the subjects within the study groups. For example the age range of infants has been eight months to 26 months (Hutcheson et al, 1993) ten months to two years (Hagekull et al, 1997) six months to 36 months (Polan et al, 1991). This large age range makes the results of these studies difficult to interpret since age rather than group allocation may be the reason for the research findings.

Once the group inclusion criteria has been established, there is the problem of obtaining parental permission to study the infants. Often research is not forthcoming with details of attrition and parental refusal. Reilly et al (1999) reported that almost 19% of their potential infant population were unavailable due to attrition, this was before they examined the remaining population of infants according to their own inclusion criteria for the research. Follow up studies can be particularly vulnerable to attrition factors. For example Dowdney et al (1987) reported that 91% of their study sample attended clinic for the first year; by 18 months this figure was reduced to 49% and by the second year the attendance was 36%. This reduces the amount of growth data available and can

affect the strength of any results found by the research. In Chapter six of this thesis there is a summary of the weight data that were available for investigation during the first year (Figure 6.1). This diagram shows the number of infants for which weight data was available. By the end of the first year the weight data available was reduced to 79% for cases (n=59) and 83% of controls (n=60). Dowdney et al (1987) reported a reduction to 91% at the end of the first year. Therefore, it is common that subject numbers will fall as the length of the study increases.

7.7 Future research

This thesis has examined early onset of failure to thrive using the Thrive Index and measured early feeding behaviour and growth from birth to the end of the first year. Throughout this discussion possible explanations for the results recorded have been explored and some areas of improvement suggested. The results shown no statistical difference between the two groups, in terms of familial characteristics, or feeding behaviour during the observational study. This suggested the familial characteristics and feeding behaviour at follow up did not necessarily explain the nature of early onset of failure to thrive. Future research could examine further the relationship between feeding and growth in infants.

Although this thesis noted no group differences on the familial characteristics, future research might investigate the home environment, especially the feeding situation. Mother and infant interaction during mealtimes as well as during other routine activities could be measured to investigate whether there are any case or control differences.

There is potential to examine this longitudinally to see how feeding problems develop and how the problems change over time.

This thesis examined early milk feeding behaviour in cases and controls. No statistically significant differences were found during the observational study. However, mothers of infants who failed to thrive described their infant's appetite less favourably than mothers of control infants and case infants were more likely to be fed on demand. Appetite and feeding schedules are variables that need to be investigated further. Energy intake in relation to body mass and intervals between feeds might be investigated by comparing case and control infants.

Future research might examine the feeding behaviour of newborn infants. This prospective study would investigate the milk feeding behaviour of infants before they failed to thrive. Another research possibility would be to examine the feeding behaviour of case and control infants at weaning and beyond. A longitudinal study might examine the case and control feeding behaviour at when solids are introduced (i.e. four months) and then at the end of the first year.

References

Agras, W. S., Kraemer, H. C., Berkowitz, R. I., & Hammer, L. D. (1990). Influence of early feeding style on adiposity at 6 years age. *The Journal of Pediatrics*, 116, 805 – 809.

Agras, W. S., Kraemer, H. C., Berkowitz, R. I., Korner, A. F., & Hammer, L. D. (1987). Does vigorous feeding style influence early development of adiposity? *The Journal of Pediatrics*, 110, 799 – 804.

Ainsworth, M. D. S., & Bell, S. M. (1969). Some contemporary patterns of mother-infant interaction in the feeding situation. In A. Ambrose (Ed.), *Stimulation in Early Infancy* (pp. 133-170): Academic Press.

Altmeier, W. A., O'Connor, S. M., Sherrod, K., & Vietze, P. M. (1984). Propective study of antecedents for nonorganic failure to thrive. *Journal of Pediatrics*, 106, 360-365.

Ardran, G. M., Kemp P. H., Lind, J. (1958). A cineradiographic study of bottle feeding. *British Journal of Radiology*, 31, 156 – 162.

Aurelius, G., Nylander, I., & Zetterstrom, R. (1987). Psychosocial factors and physical health during the first year of life. *Acta Paediatrica*, 76, 829 – 834.

Babson, S., Behrman, R., & Lessel, R. (1970). Liveborn birth weights for gestational age of white middle class infants. *Pediatrics*, 45, 937 – 943.

Batchelor, J. (1999). *Failure to Thrive in Young Children. Research and practice evaluated* (First ed.), London: The Children's Society.

Batchelor, J., & Kerslake, A. (1990). *Failure to Find Failure to Thrive* (First ed.), London: Whiting & Birch Ltd.

Beal, V. A. (1969). Termination of night feeding in infancy. *Journal of Paediatrics*, 75, 690 – 692.

Belsky, J., Robins, E., & Gamble, (1984). The determinants of parental competence: Toward a conceptual theory. In M. Lewis (Ed.), *Beyond the dyad* (pp 32 – 47). New York: Plenum Press

Benoit, D. (1993). Failure to thrive and feeding disorders. In C. Zeanah (Ed.), *Handbook of Infant Mental Health* (First ed., pp. 317 – 331), New York: Guilford Press.

Benoit, D., Zeanah, C. H., & Barton, M. (1989). Maternal attachment disturbances in failure to thrive. *Infant Medical Health Journal*, 10, 185 – 202.

Berkowitz, C. D., & Senter, S. A. (1987). Characteristics of mother-infant interactions in nonorganic failure to thrive. *The Journal Of Family Practice*, 25, 377 – 381.

Berkowitz, C. D., & Sklaren, B. C. (1984). Environmental failure to thrive - the need for intervention. *American Family Physician*, 29, 191 - 199.

Berkey, C.S., Reed, R.B., & Valadian, I. (1983). Longitudinal growth standards for pre school children. *Annals of Human Biology*, 10, 57 – 67.

Bernal, J., Richards, M. P. M. (1970). The effects of bottle and breast feeding on infant development. *Journal of Psychosomatic Medicine*, 14, 272 – 252.

Bernal, J. F. (1973). Night waking and infants during the first fourteen months. *Developmental Medicine and Child Neurology*, 15, 760 – 769.

Bernbaum, J. C., Pereira, G. R., Watkins, J. B., & Peckham, G. J. (1983). Nonnutritive sucking during Gavage feeding enhances growth and maturation in premature infants. *Pediatrics*, 71, 41 – 45.

Bilko, A., Altbacker, V. & Hudson, R. (1994). Transmission of food preference in the rabbit: the means of information transfer. *Physiology And Behaviour*, 56, 907 – 912.

Birch, L. L. & Deysher, M. (1986). Caloric compensation and sensory specific satiety: evidence for self regulation of food intake by young children. *Appetite*, 7, 323 – 331.

Birch, L. L., Johnson, S. L., Andersen, G., Peers, J. C., & Schulte, M. C. (1991). The variability of young children's energy intake. *The New England Journal of Medicine*, 24, 232 – 235.

Birch, L. L. & Fisher, J. A. (1995). Appetite and eating behaviour in children. *Paediatric Nutrition*, 42, 931 – 953.

Birch, L L & Fisher, J A (1997) Development of eating behaviours among children and adolescents. *Paediatrics*, 100, 539-549

Bithoney, W.G., & Rathbun, J (1983) Failure to thrive. In M. Levine, W Carey, R, Gross, & A. Crocker (eds) *Developmental Behavioural Pediatrics*. Philadelphia: Saunders

Bithoney, W. G. & Newberger, E. H. (1987). Child and family attributes of failure to thrive. *Developmental and Behavioural Pediatrics*, 8, 32 – 36.

Bithoney, W. G., Vansciver, M. M., Foster, S., Corso, S., & Tentindo, C. (1995). Parental stress and growth outcome in growth-deficient children. *Pediatrics*, 96, 707 – 711.

Black A. E., Cole T. J., Wiles S. J. & White F. (1983). Daily variation in food-intake of infants from 2 to 18 months. *Human Nutrition: Applied Nutrition*, 37, 448 - 458.

Black, M. M. & Krishnakumar, A. (1999). Predicting longitudinal growth curves of height and weight using ecological factors for children with and without early growth deficiency. *American Society for Nutritional Sciences*, 129, 539S - 543S.

Blurton-Jones, N., Rossetti Ferreira, M. C., Farquar-Brown, M. & Macdonald, L. (1978). The association between perinatal factors and late night waking. *Developmental Medicine and Child Neurology*, 20, 427 – 434.

Bosma, J. F., Hepburn, L. G., Josell, S. D., & Baker, K. (1990). Ultrasound demonstration of tongue motions during suckle feeding. *Developmental Medicine and Child Neurology*, 32, 223 – 229.

- Bowen-Jones, A., Thompson, C., & Drewett, R. F. (1982). Milk flow and sucking rates during breast feeding. *Developmental Medicine and Child Neurology*, 24, 626 – 633.
- Bradley, R. H., & Casey, P. H. (1992). Family environment and behavioural development of low-birthweight children. *Developmental Medicine and Child Neurology*, 34, 822 – 832.
- Brandon, S. (1970). An epidemiological study of eating disturbances. *Journal of Psychosomatic Research*, 14, 253 - 257.
- Brandt, I. (1985). Growth dynamics of low birth weight infants. *Acta Paediatrica Scandinavica*, 319, 38 – 47.
- Bridger, W. H. (1962). Ethological concepts and human development. *Recent Advances In Biological Psychiatry*, 4, 97 – 107.
- Bruch, H. (1974). *Eating Disorders, Obesity, Anorexia Nervosa And The Person Within*. London: Routledge & Kegan.
- Budd, K., Chugh, C., & Berry, S. (1998). Parents as therapists for children's food refusal problems. In J. Briesmeister & C. Schaefer (Eds.), *Handbook of Parent Training* (Second ed., pp. 418-440), Chichester: Wiley.
- Bu'Lock, F., Woolridge, M. W., & Baum, J. D. (1990). Development of co-ordination of sucking, swallowing and breathing: untrasound study of term and pre term infants. *Developmental Medicine and Child Neurology*, 32, 669 – 678.

Caldwell, B. & Bradley, R. (1984). *Home Observation For The Measurement Of The Environment*. Little Rock : University of Arkansas at Little Rock.

Campbell, I. (1958) Duration of night feeding in infancy. *Lancet*, 1, 887.

Campbell, R. G. (1976). A note on the use of feed flavour to stimulate the feed intake of weanling pigs. *Animal Production*, 23, 417 – 419.

Campfield, L. A., Brandon, P. & Smith, F. J. (1985). On line continuous measurement of blood glucose and meal pattern in feeding rats: the role of glucose in meal initiation. *Brain Research Bulletin*, 14, 605 – 615.

Campfield, L. A. & Smith, F. J. (1986). Functional coupling between transient declines in blood glucose and feeding behaviour: temporal relationships. *Brain Research Bulletin*, 17, 427 – 433.

Campfield, L. A. (1990). Transient declines in blood glucose signals meal initiation. *International Journal Of Obesity*, 14, 15 – 33.

Capretta, P. J., Petersik, J. T., & Stewart, D. J. (1975). Acceptance of novel flavours is increased after early experience of diverse tastes. *Nature*, 254, 689 – 691.

Carey, W. B. (1985). Temperament and increased weight gain in infancy. *Developmental and Behavioural Pediatrics*, 6, 128 – 131.

Carey, W. B. & McDevitt, S. C. (1978). Stability and change in individual temperament diagnoses from infancy to early childhood. *Journal of the American Academy of Child Psychiatry*, 17, 331 – 337.

Casaer, P., Daniels, H., Devlieger, H., De Cock, P., & Eggermont, E. (1982). Feeding behaviour in pre term neonates. *Early Human Development*, 7, 331 – 346.

Casey, P. H., & Arnold, W. C. (1985). Compensatory growth in infants with severe failure to thrive. *Southern Medical Journal*, 78, 1057 – 1060.

Casey, P. H., Bradley, R., & Wortham, B. (1984). Social and nonsocial home environments of infants with nonorganic failure to thrive. *Pediatrics*, 73, 348 – 353.

Casey, P. H., Kraemer, H., Bernbaum, J., Yogman, M., & Sells, J. (1991). Growth status and growth rates of a varied sample of low birth weight, preterm infants: a longitudinal cohort from birth to three years of age. *Journal of Pediatrics*, 119, 599 – 605.

Chapin, H. D. (1908). A plan of dealing with atrophic infants and children. *Archives of Pediatrics*, 25, 491 – 496.

Chapin, H. D. (1915). Are institutions for infants necessary? *Journal of the American Medical Association*, 64, 1 – 3.

Chase, H., & Martin, H. (1970). Under nutrition and child development. *The New England Journal of Medicine*, 283, 933 – 939.

Chatoor, I (1989) Infantile anorexia nervosa: a developmental disorder of separation and individuation. *Journal of the American Academy of Psychology*, 17, 43-53

Chatoor, I., & Egan, J. (1983). Nonorganic failure to thrive and dwarfism due to food refusal: a separate disorder. *Journal of the American Academy of Child Psychiatry*, 22, 294 – 301.

Chatoor, I., Ganiban, J., Colin, V., Plummer, N., & Harmon, R. (1998). Attachment and feeding problems: a re examination of nonorganic failure to thrive and attachment insecurity. *Journal of American Academic Child & Adolescent Psychiatry*, 37, 1217 – 1224.

Chatoor, I., Hirsch, R., & Persinger, M. (1997). Facilitating internal regulation of eating: A treatment model for infantile anorexia *Infants and Young Children*, 9, 12 – 22.

Chatoor, I., Schaeffer, S., Dickson, L., Egan, J., Conners, K., & Leong, N. (1984). Pediatric assessment of nonorganic failure to thrive. *Pediatric Annals*, 13, 844 – 850.

Chetwynd, A. G., Diggle, P. J., Drewett, R. F. & Young, B. (1998). A mixture model for sucking patterns of breast fed infants. *Statistics in Medicine*, 17, 395 – 405.

Cockburn, F. (1995). Breast feeding and the infant human brain. In D. P. Davies (Ed.), *Nutrition and Child Health* (First ed., pp. 1 – 12). London: Royal college of Physicians of London.

Cohen, J. (1988). *Statistical power analysis for behavioural sciences* (2nd ed.) New York: Academic press.

Cohen, J. (1992). A power primer. *Psychological Bulletin*, 112, 155 - 159.

Cole, T. J. (1990). The LMS method for constructing normalized growth standards. *Journal of Clinical Nutrition*, 44, 45 – 60.

Cole, T. J. (1994). Do chart centiles need a facelift? *British Medical Journal*, 308, 641 – 642.

Cole, T. J. (1995). Conditional reference charts to assess weight gain in British infants. *Archives of Disease in Childhood*, 73, 8 – 16.

Cooke, R. A. F., Werkman, S., Conner, C., & Watson, D. (1993). Postnatal growth in infants born between 700 and 1500g. *Journal of Pediatric Gastroenterology and Nutrition*, 16, 130 – 135.

Coolbear, J., & Benoit, D. (1999). Failure to thrive: risk for clinical disturbance of attachment? *Infant Mental Health Journal*, 20, 87 – 104.

Corbett, S. S., Drewett, R. F., & Wright, C. M. (1996). Does a fall down a centile chart matter? The growth and development sequelae of mild failure to thrive. *Acta Paediatrica*, 85, 1278 – 1283.

- Cowett, R. M., Lipsitt, L. P., Vohr, B., & Oh, W. (1978). Aberrations in sucking behaviour of low birthweight infants. *Developmental Medicine and Child Neurology*, 20, 701 – 709.
- Crittenden, P. (1987). Nonorganic failure to thrive: deprivation or distortion? *Infant Mental Health Journal*, 8, 51 – 64.
- Crump, E. P., Gore, P. M., & Horton, C. P. (1958). The sucking behaviour in pre term infants. *Human biology*, 30, 128 – 141.
- Dahl, M. (1987). Early feeding problems in an affluent society. Follow-up at two years: natural course, health, behaviour and development. *Acta Paediatrica Scandinavia*, 76, 872 – 880.
- Dahl, M., & Kristiansson, B. (1987). Early feeding problems in an affluent society. Impact on growth up to two years of age. *Acta Paediatrica Scandinavia*, 76, 881 – 888.
- Dahl, M., & Sundelin, C. (1992). Feeding problems in an affluent society. Follow-up at four years of age in children with early refusal to eat. *Acta Paediatrica*, 81, 575 – 579.
- Daniels, H., Devlieger, H., Casaer, P., Ramaekers, V., Van Den Broeck, J., & Eggermont, E. (1988). Feeding, behavioural state and cardiorespiratory control. *Acta Paediatrica Scandinavia*, 77, 369 – 373.
- Davies, D. P. (1980). Early growth of overweight and underweight babies at birth. *Proceedings of the Nutrition Society*, 39, 25 – 31.

Davies, D. P. (1981). Growth of 'small for date' babies. *Early Human Development*, 5, 95 – 105.

Davies, D. P. (1995). Human milk: a sacred cow? a quest for optimum nutrition for pre term babies. In D. P. Davies (Ed.), *Nutrition and child health* (First ed., pp. 53 – 66). London: Royal College of Physicians of London.

Davies, D. P., Gary, O. P., Elwood, A. C., Hopkinson, C., & Smith, S. (1977). The effect of solid foods on growth of bottle fed infants in the first three months of life. *British Medical Journal*, 1, 7.

Davies, D.P. & Williams, T. (1983) Is weighing babies in clinics worthwhile? *British Medical Journal*, 286, 860-863

Davis, D. R., Apley, J., Fill, G., & Grimaldi, C. (1978). Diet and retarded growth. *British Medical Journal*, 1, 539 – 542

Degangi, G., & Greenspan, S. (1989). *Test of Sensory Functions in Infants*. Western Psychological Services.

Degangi, G., Poisson, S., Sickel, R., & Weiner, A. (1995). *Infant / Toddler Symptom Checklist: A screening tool for parents*. San Antonio, TX : Therapy Skill Builders.

Deitz, W. H. (1983). Childhood obesity: susceptibility, cause and management. *Journal Of Pediatrics*, 103, 676 – 680.

DeMonterice, D., Meier, P. P., Engstrom, J. L., Crichton, C. L., & Mangurten, H. H. (1992). Concurrent validity of a new instrument for measuring nutritive sucking in pre term infants. *Nursing Research*, 41, 342 – 346.

De Vries, J., Stubbe, J. H., Wildering, W. C., Gorter, J. A., & Prins, A. J. A. (1993). Patterns of body temperature during feeding in rats under varying body temperature. *Physiology of Behaviour*, 53, 229 – 235.

Dewey, K. G., Peerson, J. M., Heinig, M. J., Nommsen, L. A., Lonnerdal, B., Lopez de Romania, G., Creed de Kanashiro, H., Black, R. E., & Brown, K. H. (1992). Growth patterns of breast-fed infants in affluent (United States) and poor (Peru) communities: implications for timing of complementary feeding. *American Journal of Clinical Nutrition*, 56, 1012 – 1018.

Dobbing, J. (1984). Infant nutrition and later development. *Nutrition Reviews*, 42, 1 – 7.

Dowdney, L., Skuse, D. H., Heptinstall, E., Puckering, C., & Zur-Szpiro, S. (1987). Growth retardation and developmental delay amongst inner-city children. *Journal of Child Psychology and Psychiatry*, 28, 529 – 541.

Drabman, R. S., Hammer, D., & Jarvie, G. J. (1977). Eating styles of obese and non obese black and white children in a naturalistic setting. *Addictive Behaviour*, 2, 83 – 86.

Drabman, R. S., Cordua, G., Hammer, D., Jarvie, G. J., & Horton, W. (1979). Developmental trends in eating rates of normal and obese preschool children. *Child Development*, 50, 211 – 216.

Drewett, R. F., & Amatayakul, K. (1999). Energy intake, appetite and body mass in infancy. *Early Human Development*, 56, 75-82

Drewett, R. F., Payman, B. C., & Whitely, S. (1987). Effect of complementary feeds on sucking and milk intake in breastfed babies: an experimental study. *Journal of Reproductive and Infant Psychology*, 5, 133 – 143.

Drewett, R. F., & Woolridge, M. W. (1979). Sucking patterns in human babies on the breast. *Early Human Development*, 3, 315 – 320.

Drotar, D., Eckerle, D., Satola, J., Pallotta, J., & Wyatt, B. (1990). Maternal interactions behaviour with nonorganic failure to thrive infants: a case comparison study. *Child Abuse and Neglect*, 14, 41 – 51.

Dubowitz, H. (1989). Prevention of child maltreatment - what is known. *Pediatrics*, 83, 570 – 577.

Eckerman, C., Sturm, L., & Gross, S. (1985). Different developmental courses for very low birth weight infants differing in early head growth. *Developmental Psychology*, 21, 813 – 827.

Edwards, A., Halse, P., Parkin, J., & Waterson, A. J. R. (1990). Recognising failure to thrive in early childhood. *Archives of Disease in Childhood*, 65, 1263 – 1265.

Edwards, A., Halse, P., & Waterson, T. (1994). Does poor weight gain identify children in need. *Child Abuse Review*, 3, 107 – 119.

Egemen, A., Kusin, N., Aksit, S., Emek, M., & Kurugol, Z. (2002) A generally neglected threat in infant nutrition: incorrect preparation of infant formulae. *The Turkish journal of pediatrics*, 44, 298 – 303.

Eishima, K. (1991). The analysis of sucking behaviour in newborn infants. *Early Human Development*, 27, 163 – 173.

Elder, M. S. (1970). The effects of temperature and position on the sucking pressure of newborn infants. *Child Development*, 41, 95 – 102.

Elliman, A. E. B., Elliman, A. J. W., & Harvey, D. (1992). The growth of low birth weight children. *Acta Paediatrica*, 81, 311 – 314.

Feldman, M., Garrick, M., & Case, L. (1997). The effects of parent training on weight gain of nonorganic failure to thrive children of parents with intellectual disabilities. *Journal of Developmental Disabilities*, 5, 47 – 61.

Field, M. (1984). Follow-up developmental status of infants hospitalised for nonorganic failure to thrive. *Journal of Pediatric Psychology*, 9, 241 – 256.

Field, T., Ignatoff, E., Stringer, S., Brennan, J., Greenberg, R., Widmayer, S., & Anderson, G. C. (1982). Nonnutritive sucking during tube feeding: Effects on preterm neonates in an intensive care unit. *Pediatrics*, 70, 381 – 384.

Flores-Heurta, S., Hernandez-Montes, H., Argote, R. M., & Villapando, S. (1992). Effects of ethanol consumption during pregnancy and lactation on the outcome and postnatal group of the offspring. *Annals of Nutrition and Metabolism*, 36, 121 – 128.

Fomon, S. J., Haschke, F., Ziegler, E. E., & Nelson, S. E. (1982). Body-composition of reference children from birth to age 10 years. *American Journal Of Clinical Nutrition*, 35, 1169 – 1175.

Fomon, S. J., Thomas, L. N., Filer, J. L., Anderson, T. A., & Nelson, S. E. (1975). Influence of formula concentration on caloric intake and growth of normal infants. *Acta Paediatrica*, 64, 172 – 181.

Fomon, S. J., Thomas, L. N., Filer, J. L., Anderson, T. A., & Nelson, S. E. (1976). Influence of fat and carbohydrate content of diet on food intake and growth of male infants. *Acta Paediatrica*, 65, 136 – 144.

Frank, D. A., & Zeisel, S. H. (1988). Failure to thrive. *The Pediatric Clinics of North America*, 35, 1187 – 1206.

Freeman, J. V., Cole, T. J., Jones, P. R. M., White, E. M., & Preece, M. A. (1995). Cross sectional stature and weight reference curves for the UK, 1990. *Archives of Disease in Childhood*, 73, 17 – 24.

Fullard, W., McDevitt, S., Carey, W. (1984). Assessing temperament in one to three year old children. *Journal of Pediatric Psychology*, 9, 205 – 216.

Galef, B. G., & Henderson, P. W. (1972). Mothers milk: a determinant of the feeding preferences of rat pups. *Journal Of Comparative Physiological Psychology*, 78, 213 – 219.

Galef, B. G., & Sherry, D. F. (1973). Mother's milk: a medium for transmission of cues reflecting the flavour of mother's diet. *Journal Of Comparative Physiological Psychology*, 83, 374 – 378.

Gaul, D. J., Craighead, W. E., & Mahoney, J. J. (1975). Relationship between eating rates and obesity. *Journal Of Consultant Clinical Psychology*, 43, 123 – 125.

Giani, U., Filosa, A., & Causa, P. (1996). A non-linear model of growth in the first year of life. *Acta Paediatrica*, 85, 7 – 13.

Gill, A., Yu, V. Y. H., Bajuk, B., & Astbury, J. (1986). Postnatal growth in infants born before 30 weeks' gestation. *Archives of Disease in Childhood*, 61, 549 – 553.

Glaser, H., Heagarty, M., Bullard, D., & Pivchik, E. (1968). Physical and psychological development of children with early failure to thrive. *Journal of Pediatrics*, 73, 690 – 698.

Goldman, A. S., Thorpe, L. W. Goldblum, R. M., & Hanson, L. A. (1986) Anti-inflammatory properties of human milk. *Acta Paediatrica Scandinavia*, 75, 689 – 695.

Gremse, D., Lytle, J., Sacks, A., & Balistreri, W. (1998). Characterization of failure to imbibe in infants. *Clinical Pediatrics*, 37, 305 – 309.

Guedeney, A. (1997). From early withdrawal reaction to infant depression: a baby alone does exist., *Infant Mental Health Journal*, 18, 339 – 349.

Hafstrom, M., Lundquist, C., Lindercrantz, K., Larsson, K., & Kjellmer, I. (1997). Recording non nutritive sucking in the neonate. Description of an automatized system for analysis. *Acta Paediatrica Scandinavia*, 86, 82 – 90.

Hagekull, B., Bohlin, G., & Rydell, A. (1997). Maternal sensitivity, infant temperament, and the development of early feeding problems. *Infant Mental Health Journal*, 18, 92 – 106.

Halverson, H. M. (1944). Mechanisms of early infant feeding. *Journal of Genetic Psychology*, 64, 185 – 223.

Hammil, P.V.V., Drizd, T.A., Johnson, C.L.L., Reed, R.B., Roche, A.F. (1976) NCHS Growth charts. *Monthly Vital Statistics*, report 25, 3 (supplement) DHEW pub.no. (HRA) 76

Hampton, D. (1996). Resolving the feeding difficulties associated with nonorganic failure to thrive. *Child Care Health and Development*, 22, 261 – 271.

Harris, G. (1993). Feeding problems and their treatment. In I. St. James-Roberts & G. Harris & D. Messer (Eds.), *Infant Crying, Feeding and Sleeping: Development, problems and treatments*. (pp. 118 – 132), New York: Harvester Wheatsheaf.

Healy, M.J.R. (1978) Notes on the statistics of growth standards. *Annals of Human Biology*, 1, 41-46

Heine, W., Hernell, O., Koletzko, B., Launiala, K., Rey, J., Rubino, A., Schoch, G., Senterre, J., & Tormo, R. (1991). Comment on the content and composition of lipids in infant formulas. *Acta Paediatrica Scandinavia*, 80, 887 – 896.

Heptinstall, E., Puckering, C., Skuse, D. H., Start, K., Zur-Szpiro, S., & Dowdney, L. (1987). Nutrition and mealtime behaviour in families of growth retarded children. *Human Nutrition: Applied Nutrition*, 41A, 390 – 402.

Hewitt, E., & Aldrich, A. (1946). Poor eating habits of the runabout child: The role of physiologic anorexia. *Journal of Pediatrics*, 28, 595 – 596.

Hill, A., & Volpe, J. J. (1981). Disorders of sucking and swallowing in the newborn infant: clinicopathological correlations, *Progress in Perinatal Neurology*, 1, 157 – 181.

Himms-Hagen, J. (1995a). Role of brown adipose tissue thermogenesis in the control of thermoregulatory feeding in rats. *Proceedings of the Society for Experimental Biology and Medicine*, 208, 159 – 169.

Himms-Hagen, J. (1995b). Does thermoregulatory feeding occur in new-born infants? *Obesity Research*, 3, 361 – 369.

Humphry, R. & Rourke, M. (1991). When an infant has a feeding problem. *Occupational Therapy Journal of Research*, 11, 106 – 120.

Hutcheson, J.J., Black, M.M. & Starr, R.H. (1993) Developmental differences in interactional characteristics of mothers and their children with failure to thrive. *Journal of Pediatric Psychology*, 18, 453 – 466.

Illingworth, R. S., & Lister, J. (1964). The critical or sensitive period, with special reference to certain feeding problems in infants and children. *The Journal of Pediatrics*, 65, 839 – 848.

Ingram, T. T. S. (1962). Clinical significance of the infantile feeding reflexes. *Developmental Medicine and Child Neurology*, 4, 159 – 169.

Itabashi, K., Takeuchi, T., Hayashi, T., Okuyama, K., Kuriya, N., & Otani, Y. (1994). Postnatal reference growth curves for very low birth weight infants. *Early Human Development*, 37, 151 – 160.

Kaye, K. (1972). *Milk pressure as a determinant of the burst-pause in neonatal sucking*. Paper presented at the 80th Annual Convention, American Pediatric Association.

Kaye, K., & Wells, A. J. (1980). Mothers' jiggling and the burst-pause pattern in neonatal feeding. *Infant Behaviour and Development*, 3, 29 – 46.

Keen, D., & Pearse, R. (1985). Birthweight between 14 and 42 weeks' gestation. *Archives of Disease in Childhood*, 60, 440 – 446.

Kelleher, K. J., Casey, P. H., Bradley, R. H., Pope, S. K., Whiteside, L., Barrett, W., Swanson, M. E., & Kirby, R. S. (1993). Risk factors and outcomes for failure to thrive in low birth weight pre term infants. *Pediatrics*, 91, 941 – 948.

Klish, W. J., Baker, S., Cochran, W. J., Flores, C. A., Georgieff, M. K., Jacobson, M., & Lake, A. M. (1988). *Pediatric Nutrition Handbook* (First ed.). Illinois: American Academy of Pediatrics.

Korner, A. F., Chuck, B. & Dontchos, S. (1968). Organismic determinants of spontaneous oral behaviour in neonates. *Child Development*, 39, 1145 – 1157.

Korner, A. F. (1973). Sex differences in new-borns with special references to differences in the organisation of oral behaviour. *Journal of Child Psychology And Psychiatry And Allied Disciplines*, 14, 19 – 29.

Kottelchuck, M. (1977). Child abuse: Prediction and misclassification. Paper presented at the conference on the Prediction of Child Abuse, Wilmington, Delaware, July 1977. In R. Starr (Ed.) *The Prediction of Child Abuse*.

Kottelchuck, M. (1980). Nonorganic failure to thrive: the status of interactional and environmental etiologic theories. *Advances in Behavioural Pediatrics*, 1, 29 – 39.

Kottelchuck, M. & Newberger, E. H. (1983). Failure to thrive a controlled study of familial characteristics. *Journal of the American Academy of Child Psychiatry*, 22, 322 – 328.

Kramer, M. S. (1981) Do breast feeding and delayed introduction of solids protect against subsequent obesity? *Journal of Pediatrics*, 98, 883 – 890.

Kramer, M. S., Barr, R. G & Ludec, D. G. (1983) Maternal psychological determinants of infant obesity: development and testing of two new instruments. *Journal of Chronic Disease*, 36, 329 – 341.

Kramer, M. S., Barr, R. G., Leduc, D. G., Boisjoly, C., McVey-White, L., & Pless, I. B. (1985). Determinants of weight and adiposity in the first year of life. *Journal of Pediatrics*, 106, 10 – 14.

Kron, R. E., Ipsen, J., & Goddard, K. E. (1968). Consistent individual difference in the nutritive sucking behaviour of the human newborn. *Psychosomatic Medicine*, 30, 151 – 161.

Lachenmeyer, J. (1998). Parent training for failure to thrive. In J. Briesmeister & C. Schaefer (Eds.), *Handbook of Parent Training* (Second ed., pp. 261 – 345), Chichester: Wiley.

Leibowitz, S. F., Weiss, G. F., & Shorposner, G. (1987). Medial hypothalamic serotonin in the control of eating behaviour. *International Journal of Obesity*, 11, 109 – 123.

Le Magnen, J. (1985) *Hunger*. London: Cambridge University Press

Lewis, J. A. (1982). Oral motor assessment and treatment of feeding difficulties. In P. J. Accarso (Ed.) *Failure to Thrive in Infancy and Early Childhood*. Baltimore: University Park Press.

Lloyd-Still, J., Hurwitz, I., Wolff, P., & Shwachman, H. (1974). Intellectual development after severe malnutrition in infancy. *Pediatrics*, 54, 306 – 311.

Little, R. E., Anderson, K. W., Ervin, C. H., Worthington-Roberts, B. & Clarren, S. (1989). Maternal alcohol use during breast feeding and infant motor development at one year. *New England Journal Of Medicine*, 321, 425 – 430.

Lobo, M. L., Barnard, K. E., & Coombs, J. B. (1992). Failure to thrive: A parent-infant interaction perspective. *Journal of Pediatric Nursing*, 7, 251 – 261.

Lucas, A., Morley, R., Cole, T. J., & Gore, P. M. (1994). A randomised multicentre study of human milk versus formula and later development in preterm infants. *Archives of Disease in Childhood*, 70, 141 – 146.

Lucas, A. & Cole, T. J. (1990) Breast milk and neonatal enterocolitis. *The Lancet*, 336, 1519 – 1523.

Lucas, A., Morley, R., Cole, T. J., Gore, S. M., Davis, J.A., Bamford, M.F.M. & Dossetor, J.F.B. (1989) Early diet in preterm infants and developmental status in infancy. *Archives of Disease in Childhood*, 64, 1570 – 1578.

Lucas, A., Morley, R., Cole, T. J., Gore, S. M., Lucas, P., Crowle, P., Pearce, R., Boon, A., & Powell, R. (1990). Early diet in pre term babies and developmental status at 18 months. *Lancet*, 335, 1477 – 1481.

Mainardi, M., Poli, M., & Valsecchi, P. (1989). Ontogeny of dietary selection in weanling mice: effects of early experience and mother's milk. *Biological Behaviour*, 14, 185 – 194.

Maone, T. R., Mattes, R. D., Bernbaum, J. C., & Beauchamp, G. K. (1990). A new method for delivering a taste without fluids to preterm and term infants. *Developmental Psychobiology*, 23, 179 – 191.

Maggioni, A., & Lifshitz, F. (1995) Nutritional management of failure to thrive. *Pediatric Clinics Of North America*, 42, 791 – 810.

Marchi, M., & Cohen, P. (1990). Early childhood eating behaviours and adolescent eating disorders. *Journal of the American Academy of Child and Adolescent Psychiatry*, 29, 112 – 117.

Martin, J. (1978). *Infant Feeding 1975*. Office Of Population Censuses and Surveys, Social Survey Division SS1064, HMSO, London

Marsh, F. (1988). A program to produce a complete record of behaviour observed by researchers in the field. *Master's Thesis*, Department of Computing Science, University of Newcastle upon Tyne, England.

Mathew, O. P. (1988). Nipple units for newborn infants: a functional comparison. *Pediatrics*, 81, 688 – 691.

Mathew, O. P. (1990). Determinants of milk flow through nipple units. Role of hole size and nipple thickness. *American Journal of Diseases in Children*, 144, 222 – 224.

Mathew, O. P. (1991a). Science of bottle feeding. *The Journal of Pediatrics*, 119, 511 – 519.

Mathew, O. P. (1991b). Sucking and breathing patterns of pre term infants with low and high flow laser cut nipple units. *Pediatric Research*, 29, A226.

Mathew, O. P. (1991c). Milk flow variability is reduced among laser-cut nipple units. *Pediatric Research*, 29, 226a.

Mathew, O. P., & Bhatia, J. (1989). Sucking and breathing patterns during breast and bottle feeding in term neonates. Effects of nutrient and delivery composition. *American Journal of Diseases in Children*, 143, 588 – 592.

Mathisen, B., Reilly, S., & Skuse, D. (1992). Oral-motor dysfunction and feeding disorders of infants with turner syndrome. *Developmental Medicine And Child Neurology*, 34, 141 – 149.

Mathisen, B., Skuse, D. H., Wolke, D., & Reilly, S. (1989). Oral-motor dysfunction and failure to thrive among inner-city infants. *Developmental Medicine and Child Neurology*, 31, 293 – 302.

- McGowan, J. S., Marsh, R. R., Fowler, S. M., Levy, S. E., & Stallings, V. A. (1991). Developmental patterns of normal nutritive sucking in infants. *Developmental Medicine and Child Neurology*, 33, 891 – 897.
- Mennella, J. A., & Beauchamp, G. K. (1991a) Maternal Diet alters the sensory qualities of human milk and the nurselings behaviour. *Paediatrics*, 88, 737 – 744.
- Mennella, J. A., & Beauchamp, G. K. (1991b) The transfer of alcohol to human milk. The effects on flavour and the infant's behaviour. *Journal of Medicine*, 325, 981 – 985.
- Mennella, J. A., & Beauchamp, G. K. (1993). The effects of repeated exposure to garlic flavoured milk on the nurselings behaviour. *Paediatric Research*, 34, 805 – 808.
- Mennella, J. A., & Beauchamp, G. K. (1996). The human infants response to vanilla flavours in mothers milk and formula. *Infant Behaviour and Development*, 19, 13 – 19.
- Mitchell, E. A., Ford, R. P. K., & Taylor, B. J. (1992). Further evidence supporting a causal relationship between prone sleeping and SIDS. *Journal Of Paediatric Child Health*, 28, S9 – 12.
- Mitchell, W.G., Gorrell, R. W., & Greenberg, R. A. (1980). Failure to thrive: a study in the primary care setting. Epidemiology and follow up. *Pediatrics*, 65, 971 – 977.
- Moore, J. (1997). Feeding to thrive in babies and small children. *Community Nurse*, 3, 23 – 24.

Morgan, J. B., Kimber, A. C., & Stordy, R. J. (1995). Healthy eating for infants - mothers' attitudes. *Acta Paediatrica*, 84, 512 – 515.

McIntosh, J. (1985). Barriers to breastfeeding: choice of feeding method in a sample of working class primiparae. *Midwifery*, 1, 213 – 224.

Montgomery, S. M., Bartley, M. J., & Wilkinson, R. G. (1997). Family conflict and slow growth. *Archives of Disease in Childhood*, 77, 326 – 330.

Morley, R., & Lucas, A. (1995). The influence of early diet on outcome in pre term infants. In D. P. Davies (Ed.), *Nutrition and child health* (pp. 67- 76). London: Royal College Of Physicians of London.

Myres, A. W. & Young, D. L. (1979). Obesity in infants: significance, aetiology and prevention. *Canadian Journal Of Public Health*, 70, 113 – 119.

National Centre for Health Statistics Percentiles. Adapted from P. V. V. Hammil, H. Drizd, C. L. Johnson, R. B. Reed, H. F. Roche & B. Moore (1979). Physical growth: National centre for health statistics percentiles. *American Journal of Clinical Nutrition*, 12, 607 – 629.

Newton, N. R. (1951). The relationship between infant feeding experience and later behaviour. *Journal of Pediatrics*, 38, 28 – 40.

Nisbett, R. E., & Gurwitz, S. B. (1970). Weight, sex, and the eating behaviour of human newborns. *Journal of Comparative and Physiological Psychology*, 73, 245 – 253.

Nolte, D. L. & Provenza, F. D. (1991). Food preferences in lambs after exposure to flavours in milk. *Applied Animal Behaviour Analysis*, 32, 381 – 389.

Nylander, I., Rydelius, P. A., Nordberg, L., Aurelius, G., & Zetterstrom, R. (1989). Infant health and development in relation to family situation. *Acta Paediatrica Scandanavia*, 78, 1 – 10.

Oates, R. (1989). The consequences of child abuse and neglect. *Early Child Development and Care*, 42, 57 – 69.

Oates, R., Peacock, A., & Forrest, D. (1984). development in children following abuse and nonorganic failure to thrive. *American Journal of Diseases in Children*, 138, 764 – 767.

Oates, R., Peacock, A., & Forrest, D. (1985). Long term effects of nonorganic failure to thrive. *Pediatrics*, 75, 36 – 40.

Oates, R. K., & Yu, J. S. (1971). Children with non-organic failure to thrive. A community problem. *The Medical journal of Australia*, 2, 199 – 203.

Palmer, M. M., Crawley, K., & Blanco, I. A. (1993). Neonatal oral-motor assessment scale: a reliability study. *Journal of Perinatology*, 13, 28 – 34.

Peiper, A. (1961). Die Eigenart der kindlichen Hirntatigkeit. Auflage 3. Leipzig: Thieme cited in Mathew, O. P. (1991). Science of bottle feeding. *The Journal Of Pediatrics*, 119, 511 – 519.

Peterson, K. E., Rathbun, J. N., & Herrera, M. G. (1985). Growth analysis in failure to thrive treatment and research. In D. Drotor (Ed.), *New Directions in Failure to Thrive*. (First ed., pp. 157-176). New York and London: Plenum Press.

Polan, J. H., Leon, A., Kaplan, M. D., Kessler, D. B., Stern, D. N., & Ward, M. J. (1991). Disturbances of affect expression in failure to thrive. *Journal of American Academic Child Adolescent Psychiatry*, 30, 897 – 903.

Polan, J. H., & Ward, M. J. (1994). Role of mother's touch in failure to thrive: a preliminary investigation. *Journal of American Academic Child Adolescent Psychiatry*, 33, 1098 – 1105.

Pollitt, E., & Leibel, R. (1980) Biological and social correlates of failure to thrive. In L. Green & E. E. Johnson (Eds) *Social and biological predictors of nutritional status, physical growth, and neurological development* (pp173 – 200). New York: Academic Press

Poskitt, E. M. E., & Cole, T. J. (1978). Nature, nurture and childhood overweight. *British Medical Journal*, 1, 603 – 605.

Potur, A., & Kalmaz, N. (1996) An investigation into feeding errors of 0-4 month old infants. *Journal of tropical pediatrics*, 42, 173 –175.

Powell, G. F. (1983). Behaviour in nonorganic failure to thrive. *Journal of Developmental and Behavioral Pediatrics*, 4, 26 - 33.

Powell, G. F. (1988). Nonorganic failure to thrive in infancy: an update on nutrition, behaviour, and growth. *Journal of the American College of Nutrition*, 7, 345 – 353.

Preece, M.A., Freeman, J.V. & Cole, T.J. (1996) Sex differences in weight in infancy: Published centile charts for weight have been updated. *British Medical Journal*, 313, 1486

Pugliese, M. T., Weyman-Daum, M., Moses, N., & Lifshitz, F. (1987). Parental health beliefs as a cause of nonorganic failure to thrive. *Pediatrics*, 80, 175 – 182.

Ramsey, M., Gisell, E. G., & Boutry, M. (1993). Non-organic failure to thrive: growth failure is secondary to feeding skills disorder. *Developmental Medicine and Child Neurology*, 35, 285 – 297.

Ramsey, M., & Gisell, E. G. (1996). Neonatal sucking and maternal feeding practices. *Developmental Medicine and Child Neurology*, 38, 34 – 37.

Rathburn, J. & Peterson, K. (1987). Nutrition in failure-to-thrive. In R. Grand, J. Sutphen, & W. Dietz (Eds.) *Pediatric Nutrition: Theory and Practice*. Boston: Butterworth

Raynor, P., & Rudolf, M. C. J. (1996). What do we know about children who fail to thrive? *Child: Care, Health and Development*, 22, 241 – 250.

Reilly, S., & Skuse, D. H. (1992). Characteristics and management of feeding problems of young children with cerebral palsy. *Developmental Medicine and Child Neurology*, 34, 379 – 388.

Reilly, S. M., Skuse, D. H., Wolke, D., & Stevenson, J. (1999). Oral motor dysfunction in children who fail to thrive: organic or non-organic? *Developmental Medicine and Child Neurology*, 41, 115 – 122.

Ricciuti, H. (1993). Nutritional and mental development. *Current Directions in Psychological Science*, 2, 43 – 46.

Rodriguez, S., Hildreth, G., & Mancuso, J. (1999). The dynamics of family business: how therapists can help in ways consultants don't. *Contemporary Family Therapy*, 21, 453 – 468.

Rolls, B. J., Rowe, E. S., & Rolls, E. T. (1982). How sensory properties of foods affect human feeding behaviour. *Physiology and Behaviour*, 29, 409 – 417.

Rottoli, A., Decarlis, S., Gianni, M.L., & Giovannini, M. (1997) Influence of mineral water on rheological characteristics of reconstituted infant formulas and diluted cows' milk. *The journal of international medical research*, 25, 275 – 284.

Rovee, C. K. (1972). Olfactory cues adaption and facilitation in human neonates. *Journal Of Experimental Child Psychology*, 13, 368 – 381.

Rowland, M. G. M., Paul, A. A., & Whitehead, R. G. (1981). Lactation and infant nutrition. *British Medical Bulliten*, 37, 77 – 82.

Saarinen, U. M., & Siimes, M. A. (1979). Role of prolonged breast feeding in infant growth. *Acta Paediatrica Scandinavica*, 68, 245 – 250.

Saint, L., Maggiore, P., & Hartman, E. (1986). Yield and nutrient content of milk in eight women breast-feeding twins and one woman breast-feeding triplets. *British Journal of Nutrition*, 56, 49 – 58.

Schwartz, A. S. (1958). Eating problems. *Pediatrics Clin*, 15, 595 – 611.

Schaffer-Bell, L. & Woolston, J. (1985). The relationship of weight gain and calorific intake in infants with organic and nonorganic failure to thrive syndrome. *Journal of the American Academy of Child Psychiatry*, 24, 447 – 452.

Seifer, R. & Dickstein, S. (1993) Parental mental illness and infant development. In C.H. Zeanah (ed), *Handbook of infant mental health*, (p 120 –142). New York: Guilford Press.

Shaffer, S.G, Quimiro., C.L., Anderson, J.V., & Hall, R. (1987). Postnatal weight changes in low birth weight infants. *Pediatrics*, 79, 702 – 705.

Shukla, A., Forsyth, H. A., Anderson, C. M., & Mawah, S. M. (1972). Infantile overnutrition in the first year of life: a field study in Dudley, Worcestershire. *British Medical Journal*, 4, 507 – 515.

Sinclair, J. C. (1979). *Temperature regulation and energy metabolism in the new-born*. London: Harcourt Brace Jovanovich.

Sipes-Kolberg, K. (1999). Environmental influences on prenatal development and health. In T. Whiteman & T. Merluzzi & R. White (Eds.), *Life Span Perspectives on Health and Illness* (first ed., pp. 87-103), Hove: Lawrence Erlbaum Associates.

Skuse, D. H. (1985). Non-organic failure to thrive: a reappraisal. *Archives of Disease in Childhood*, 60, 173 – 178.

Skuse, D. H., Gill, D., Reilly, S., Wolke, D., & Lynch, M. A. (1995). Failure to thrive and the risk of child abuse: a prospective population survey. *Journal of Medical Screening*, 2, 145 – 149.

Skuse, D., Gilmour, J., Tian, C.S. & Hindmarsh, P. (1994a) Psychosocial assessment of children with short stature: a preliminary report. *Acta Paediatrica Supplement*, 406, 11-16

Skuse, D. H., Pickles, A., Wolke, D., & Reilly, S. (1994b). Postnatal growth and mental development: evidence for a 'Sensitive Period'. *Journal of Child Psychology and Psychiatry*, 35, 521 – 545.

Skuse, D., Reilly, S. & Wolke, D. (1993) Psychosocial adversity and growth in infancy. *European Journal of Clinical Nutrition*, 47, 1-18

Skuse, D., Stevenson, J., Reilly, S., & Mathisen, B. (1995). Schedule for oral-motor assessment (SOMA): methods of validation. *Dysphagia*, 10, 192 – 202.

Smith, W. L., Erenberg, A., & Nowak, A. (1988). Imaging evaluation of the human nipple during breast-feeding. *American journal of diseases of children*, 142, 76 – 78.

Smith, W. L., Erenberg, A., Nowak, A., & Franken, E. A. (1985). Physiology of sucking in the normal term infant using real-time US. *Radiology*, 156, 379 – 381.

Spitz, R. A. (1945). Hospitalism: An enquiry into the genesis of psychiatric conditions of early childhood. *Psychoanalytic study of the child*, 1, 53 – 74.

Spitz, R. A. (1946). Anaclitic depression, an enquiry into the psychiatric condition of early childhood. *Psychoanalytic study of the child*, 2, 313 – 342.

Stein, M.T. (2002) Failure to thrive in a four month old nursing infant. *Developmental and behavioural pediatrics*, 23, 266-269

Stein, A., Woolley, H., Cooper, S. D., & Fairburn, C. G. (1994). An observational study of mothers with eating disorders and their infants. *Journal of Child Psychology and Psychiatry*, 35, 733 – 748.

Steward, D.K. & Garvin, B.J. (1997) Non organic failure to thrive: a theoretical approach. *Journal of Pediatric Nursing*, 12, 342-347

Stewart, M. A., Pitts, F. N., Craig, A. G., & Dieruf, W. (1966). The hyperactive child syndrome. *The American Journal of Orthopsychiatry*, 36, 861 – 867.

Stordy, R. J., Redfern, A. M., & Morgan, J. B. (1995). Healthy eating for infants - mothers' actions. *Acta Paediatrica*, 84, 733 – 741.

Strum, L. & Drotar, D. (1991). Maternal attributions of aetiology in nonorganic failure to thrive. *Family Systems Medicine*, 9, 53 – 63.

Sveger, T., Lindbert, T., Weibull, B., & Olson, U. L. (1975). Nutrition, overnutrition, and obesity in the first year of life in Malmo, Sweden. *Acta Paediatrica Scandinavia*, 64, 635 – 640.

de Sweit M., & Fayers, P. (1977) Effect of feeding habit on weight in infancy. *Lancet*, 1, 892 – 894.

Taitz, L. S. (1971). Infantile overnutrition among artificially fed infants in the Sheffield region. *British Medical Journal*, 1, 315 – 316.

Taitz, L. S. (1983). *The obese child*. London: Blackwell Scientific Publications

Tanner, J. M., Whitehouse, R. H., & Takaishi, M. (1966a). Standards from birth to maturity for height, weight, height velocity and weight velocity: British children, 1965. Part I. *Archives of Disease in Childhood*, 41, 454 – 471.

Tanner, J. M., Whitehouse, R. H., & Takaishi, M. (1966b). Standards from birth to maturity for height, weight, height velocity and weight velocity: British children, 1965. Part II. *Archives of Disease in Childhood*, 41, 613 – 627.

Tapp, W. N., Levin, B. E. & Natelson, B. H. (1981). Ultradian rythm of plasma in norepinephrine in rats. *Endocrinology*, 109, 1781 – 1783.

- Telch, C. F., Agras, W. S. & Rossiter, E. M. (1988). Binge eating increases with increasing adiposity. *International Journal Of Eating Disorders*, 7, 115 – 119.
- Terry, L. M., & Johnson, I. B. (1987). Olfactory influences on ingestive behaviour of infant rats. *Developmental Psychobiology*, 20, 313 – 332.
- Todrank, J., Wysocki, C. J., & Beauchamp, G. K. (1991). The effects of adaption on the perception of similar and dissimilar odours. *Chemical Senses*, 16, 467 – 482.
- Tolia, V (1995) Very early onset of non organic failure to thrive in infants. *Journal of Pediatric Gastroenterology & Nutrition*, 20, 73-80
- Vallerand, A. L., Persusse, F., & Buckowieki, L. J. (1987). Cold exposure potentiates the effect of insulin on in vivo glucose uptake. *American Journal Of Physiology*, 253, E179 - E186.
- Vallerand, A. L., Persusse, F. & Buckowieki, L. J. (1990). Stimulatory effect of cold exposure and cold acclimation on glucose uptake in rat peripheral tissues. *American Journal Of Physiology*, 259, R1043 - R1049.
- Wailoo, M. P., Petersen, S. A., & Whitaker, H. (1990). Disturbed nights and 3-4 month old infants: the effects of feeding and thermal environment. *Archives of Disease in Childhood*, 65, 499 – 501.
- Wales, J. K. H., & Kennedy, C. P. A. (1996). Sex differences in weight in infancy: Data from Sheffield support authors' findings. *British Medical Journal*, 313, 1486.

Ward, M. J., Kessler, D. B., & Altman, S. (1993). Infant-mother attachment in children with failure to thrive. *Infant Mental Health Journal*, 14, 208 – 220.

Waterlow, J. C., Buzina, R., Keller, W., Lane, J. M., Nichaman, M. Z., & Tanner, J. M. (1977). The presentation and use of height and weight data for comparing the nutritional status of groups of children under the age of 10 years. *Bulletin of the World Health Organisation*, 55, 489 – 498.

Weber, F., Woolridge, M. W. & Baum, J. D. (1986). An ultrasonographic study of the organisation of sucking and swallowing by newborn infants. *Developmental Medicine and Child Neurology*, 28, 19 – 24.

Weil, W. B. (1977). Current controversies in childhood obesity. *Journal of Pediatrics*, 91, 175 – 187.

Whitehead, R. G., & Paul, A. A. (1984). Growth charts and the assessment of infant feeding practices in the western world and in developing countries. *Early Human Development*, 9, 187 – 207.

Whiteman, T., White, R., O'Mara, K., & Goeke-Morey, M. (1999). Environmental aspects of infant health and illness. In T. Whiteman & T. Merluzzi & R. White (Eds.), *Life-span perspectives on health and illness* (first ed., pp. 105-124), Hove: Lawrence Erlbaum Associates.

Whitten, C. F., Pettit, M. G., & Fischhoff, J. (1969). Evidence that growth failure from maternal deprivation is secondary to underfeeding. *Journal of American Medical Association*, 209, 1675 – 1680.

WHO. (1995). An evaluation of infant growth: the use and interpretation of anthropometry in infants. *Bulletin of the World Health Organisation*, 73, 165 – 174.

Widdowson, E. M., & McCance, R. A. (1975). A review: new thoughts on growth. *Pediatric Research*, 9, 154 – 156.

Wilcox, W.D., Neiburg, P., & Miller, D.S. (1989) Failure to thrive: a continuing problem of the definition. *Clinical Paediatrics*, 28, 391-394

Winberg, J. (1995). Examining breast feeding performance: forgotten influencing factors. *Acta Paediatrica*, 84, 465 – 467.

Wilensky, D. S., Ginsberg, G., Altman, M., Tulchinsky, T. H., Yishey, F. B., & Auerbach, J. (1996). A community based study of failure to thrive in Israel. *Archives of Disease in Childhood*, 75, 145 – 148.

Wilson, L. M., Chang, S. P., Henning, S. J., & Margules, D. L. (1979). Suckling: developmental indicator of genetic obesity in mice. *Developmental Psychobiology*, 14, 67.

Wishon, P., Bennet, L., & Eller, B. (1986). The etiology, treatment and prevention of nonorganic failure to thrive in infants. *Early Child Development and Care*, 23, 107 – 123.

Wolf, L. & Glass, R. (1992). *Feeding and swallowing disorders in infancy : assessment and management*. Tucson, AZ : Therapy Skill Builders.

Wolff, P. H. (1968). The serial organisation of sucking in the young infant. *Paediatrics*, 42, 943 – 956.

Wolke, D., Meyer, R., Ohrt, B., & Riegel, K. (1995). Co-morbidity of crying and feeding problems with sleeping problems in infancy: Concurrent and predictive associations. *Early Development and Parenting*, 4, 191 – 207.

Woolridge, M. W. (1995). Breast feeding: physiology into practice. In D. P. Davies (Ed.), *Nutrition in Child Health* (First ed., pp. 3-12). London: Royal College of Physicians of London.

Woolridge, M. & Drewett, R. F. (1986). Sucking rates of human babies on the breast: a study using direct observation and intraoral pressure measurements. *Journal of Reproductive and Infant Psychology*, 4, 69 – 75.

Wooster, D. (1999). Assessment of nonorganic failure to thrive. *Infant-Toddler Intervention*, 9, 353 – 371.

Wooster, D. (2000). Intervention for nonorganic failure to thrive. *Infant-Toddler Intervention*, 10, 37 – 45.

Wren, F., & Tarbell, S. (1998). Feeding and growth disorders. In R. Ammerman & J. Campo (Eds.), *Handbook of Pediatric Psychology and Psychiatry* (Second ed., pp. 133-165), London: Allyn and Bacon.

Wright, C. M. (1995). A population approach to weight monitoring and failure to thrive. In T. J. David (Ed.), *Recent Advances In Pediatrics 13* (13th edition., 73-87): Edinburgh: Churchill, Livingstone.

Wright, C. M., Callum, J., Birks, E., & Jarvis, S. (1988). Effect of community based management in failure to thrive; randomised controlled trial. *British Medical Journal*, 29, 571 – 574.

Wright, C. M., Corbett, S. S. & Drewett, R. F. (1996). Sex differences in weight in infancy and the British 1990 national growth standards. *British Medical Journal*, 313, 513 – 514.

Wright, C. M., Matthews, J. N. S., Waterson, A., & Aynsley-Green, A. (1994). What is a normal rate of weight gain in infancy? *Acta Paediatrica*, 83, 1 – 6.

Wright, C. M., & Talbot, E. (1996). Screening for failure to thrive - what are we looking for? *Child: care, health and development*, 22, 223 – 234.

Wright, C. M., Waterson, A., & Aynsley-Green, A. (1994). Effect of deprivation on weight gain in infancy. *Acta Paediatrica*, 83, 357 – 359.

Wright, K., Dawson, J., Fallis, D., Vogot, E., & Lorch, V. (1993). New postnatal growth grids for very low birth weight infants. *Pediatrics*, 91, 922 – 926.

Wright, P., Fawcett, J., & Crow, R. A. (1980). The development of differences in the feeding behaviour of bottle and breast fed human infants. *Behavioural Processes*, 5, 1 – 20.

Wright, P. (1981). Development of feeding behaviour in early infancy: implications for obesity. *Health Bulletin*, 39, 197 – 206.

Wright, P. (1982). Nutrition and feeding In P. Stratton (Ed.) *Psychobiology of the Human Newborn* (pp. 339 – 366), London: John Wiley

Wright, P. (1986). Do breast feeding mothers know how hungry their babies are? *Midwifery*, 2, 86 – 92.

Wright, P. (1987). Mothers assessment of hunger in relation to meal size in breastfed infants. *Journal of Reproductive and Infant Psychology*, 5, 173 – 181.

Wright, P. A., Pollock, T. M., Miller, E., & Coleman, E. M. (1983). Pyrexia after diphtheria/tetanus/pertussis and diphtheria/tetanus vaccines. *Archives of Disease In Childhood*, 58, 921 – 933.

Young, B. & Drewett, R. (2000). Eating behaviour and its variability in one year old children. *Appetite*, 35, 171 – 177.

Appendix 1

Written information for health visitors



Newcastle University
Community Child Health
13 Walker Terrace
Gateshead
Tyne & Wear
NE8 3EB

MILLENNIUM BABY STUDY - Feeding and Growth Study

The Millennium Baby Study is a study of feeding and growth in infancy. Mothers with new-born babies delivered between June 1999 and June 2000 will be recruited and followed-up for one year. A range of the mothers' and baby's characteristics will be assessed so that we can investigate how babies grow after birth and how the pattern of feeding changes as they get older. As you are also concerned with mothers' and infants' health, we imagine you will find this study as interesting as we will.

It is important for this developmental study that baseline information is collected as soon after birth as possible. For the study to be successful we therefore need help from those who are most involved with the families during the latter part of pregnancy onwards. There are three areas with which we need help, only some of which will directly involve you personally. Community midwives are asked to help us trace mothers who are discharged from hospital before recruitment or do not give birth at the QEH. Ward midwives, community midwives and health visitors are each asked to rate every baby's feeding once. Health visitors are asked to provide us with the mothers' EPDS scores from the three month home visit.

We would like you to read the whole leaflet carefully, so that you get a flavour of the procedures we will be using.

The population for the study are residents of Gateshead Borough with a new-born baby, born either within or outside the area during pre-specified recruitment weeks (approximately alternate weeks over the one year period). Only those families with a baby born in a recruiting week will be eligible, and all eligible families will be asked to participate in the study. Recruitment weeks will always begin after midnight Friday one week and end the following Friday at midnight. We will recruit 1000 new-born babies delivered between June 1999 and June 2000, and follow their development for one year.

The study has ethical approval from the Local Research Ethics Committee, and we have the full support of senior midwifery, senior health visitors and consultants in the Trust. We will also need every midwife and health visitor's co-operation during the study, though only a small amount of extra work will be involved for each individual. We will supply each participating mother with a special edition of the Personal Child Health Record (PCHR) and the forms to be completed by you will be in it. The forms will have tick boxes for you to fill in and they will have carbonated copies which you can simply tear off and post to us via internal mail. You will know which mothers are in the study because the cover of their PCHR will be grey.

1. Antenatal clinics

We will supply an Antenatal Information Leaflet which all expectant women should receive during their antenatal check at 28 weeks. The leaflet outlines the study and explains that they may be asked to take part after they have delivered their baby. The leaflets will include a form which can be completed by those who agree to being phoned by the research assistant after they have had their baby. If they fill in the form and have their baby during a recruitment week but are not approached for recruitment during their hospital stay, the research assistant will phone them at home to ask if they are willing to take part in the study. We would like midwives to return the completed forms via internal mail in the addressed envelopes provided or put them in the envelope marked Millennium Baby Study in the antenatal clinic at the QEH.

The study is beginning in June 1999, so from now on midwives are asked to give each expectant mother one of the Leaflets at a time when she is receiving other literature.

2. Recruitment

It is important that families are recruited to the study very soon after birth. The research assistant will attend the maternity unit everyday during recruitment weeks. She will find out from the staff how many births there have been since the previous visit and speak to the mothers in person. It is anticipated it will be possible to approach mothers about recruitment within the maternity unit of the QEH in approximately two-thirds of cases.

On Monday of each recruitment week the research assistant will approach only those mothers who have given birth after midnight on the previous Friday. After Monday she will approach each newly admitted mother in the maternity unit. Recruiting within the unit will be conducted in as unobtrusive way as possible; priority will always be given to medical staff and the normal running of the ward.

A number of mothers deliver outside of Gateshead. As you know, outside hospitals contact the community clerk when mothers are discharged during weekdays and she lets the community midwife know. Outside hospitals contact community midwives directly when discharges occur at weekends. Because it is important for the study that we locate all eligible families as soon as possible, community midwives are asked to ensure they telephone the community clerk on Monday with the weekend discharges and the following day if mothers are discharged after 5.00 pm. Community midwives are also asked to mention the study to mothers in these circumstances (see details later). However, we have arranged to recruit mothers delivering at the RVI, Newcastle, so in the majority of cases mothers delivering there will already have been recruited by the time you visit them at home.

We appreciate that extra-sensitivity is needed in approaching families with a baby in the Special Care Baby Unit. The research assistant will speak to the staff daily to discuss each new-born baby's condition. Only those families whose baby has begun recuperating will be approached.

As families are recruited to the study, their details will be entered onto a database as a matter of priority. As soon as this occurs, a letter will be sent to the family's community midwife, health visitor and GP.

3. Ward midwife

For all babies delivered during recruitment weeks we ask that ward midwives rate the baby's feeding on the form named Maternity Hospital Discharge. For babies already recruited onto the study, the form will be in their copy of the PCHR, which will have been supplied by the research assistant while on the ward. We will supply a spare pad of these forms which will be used for all babies discharged from hospital who have not already been recruited. Please complete the form and give it to the mother with her paediatric check form. If, for any reason, a mother has not been recruited at the time of discharge and is subsequently recruited to the study, we will be able to retrieve our copy of the Maternity Hospital Discharge form at a later stage. Please return the forms by putting them in the envelope marked Millennium Baby Study on the ward.

In general, the community midwives will be rating the baby's feeding on day six when the guthrie test is performed during a home visit. However, some mothers and babies are still in hospital at day six, and the ward midwives are asked to complete the Six Day Visit form in these cases. The form will be in the mother's PCHR. The mother will have completed a milk feeding diary by this time. We ask that you retrieve the milk feeding diary and the Infant Feeding Audit and return them, with the completed Six Day Visit form, by putting them in the envelope marked Millennium Baby Study on the ward.

4. Community midwife

Hopefully, by the time community midwives see them, many of the mothers eligible to take part in the study will already have given their consent and been issued with their PCHR. They will have been encouraged to record their baby's progress in it regularly, and show the record to you.

There are two specific ways we need help from community midwives. The first applies to the recruitment of all mothers who give birth within a recruitment week and are therefore eligible to participate in the study (see (a) for details). The second applies to all the families actually recruited onto the study; we would like you to rate each participating baby's feeding during the home visit on day six (see (b) for details).

(a) Recruitment

It is very important for the study that mothers are recruited as soon after birth as possible. We are recruiting at both the QEH and RVI maternity units on a daily basis during recruitment weeks, and we anticipate that the majority of eligible mothers will be discharged from hospital as participants of the study. Mothers who are not recruited in this way fall into two categories as specified below.

i. Those that we have missed on the maternity units

When mothers are discharged from the maternity unit before recruitment is possible, we would like the community midwife to mention the study to the mother, give her a Postnatal Information Leaflet and ask if she is agreeable to her details being given to the research assistant. We ask that community midwives phone us to let us know whether the mother is agreeable to being contacted, or let the community clerk know.

ii. Those who do not give birth at either the QEH or RVI

We will not know about mothers who give birth outside Gateshead (with the exception of those we trace at the RVI). In these cases community midwives are asked to mention the study to the mother, give her the Postnatal Information Leaflet and find out whether she is agreeable to her details being given to the research assistant and being contacted by her in the near future. The community midwife is asked to phone the research assistant to let her know whether the mother is agreeable to this, or let the community clerk know.

The majority of mothers in this category will be those giving birth in the Hexham and Durham maternity units. Gateshead babies are also delivered at South Tyneside, Sunderland etc. During recruitment weeks we hope to be able to liaise very closely with the midwives who visit any mother who has not delivered at the QEH or RVI. In this way, all those mothers eligible can be asked to take part in the study.

(b) Rating of baby's feeding

During the home visit when the guthrie test is performed (day six), we ask the community midwife to rate the baby's feeding on the carbonated form named Six Day Visit form in the mother's PCHR. The mother will also have completed a milk feeding diary in her PCHR and a Infant Feeding Audit. Please extract the Six Day Visit form and the milk feeding diary from the PCHR and return them both with the Infant Feeding Audit in one of the envelopes in the front pocket of the PCHR.

5. Health visitor

There are two ways we need help from health visitors. The first is that we would like you to rate each baby's feeding during the primary visit (see (a) for details). The second is that we would like you to supply us with the mother's scores from the depression scale (see (b) for details).

(a) Rating of baby's feeding

During health visitors' primary visit, we ask that you rate the baby's feeding on the carbonated form named Primary Visit in the PCHR. We would also like you to supply us with the baby's weight on the same form and return our copy of the information in the addressed envelope in the front of the PCHR.

(b) Scores from depression scale

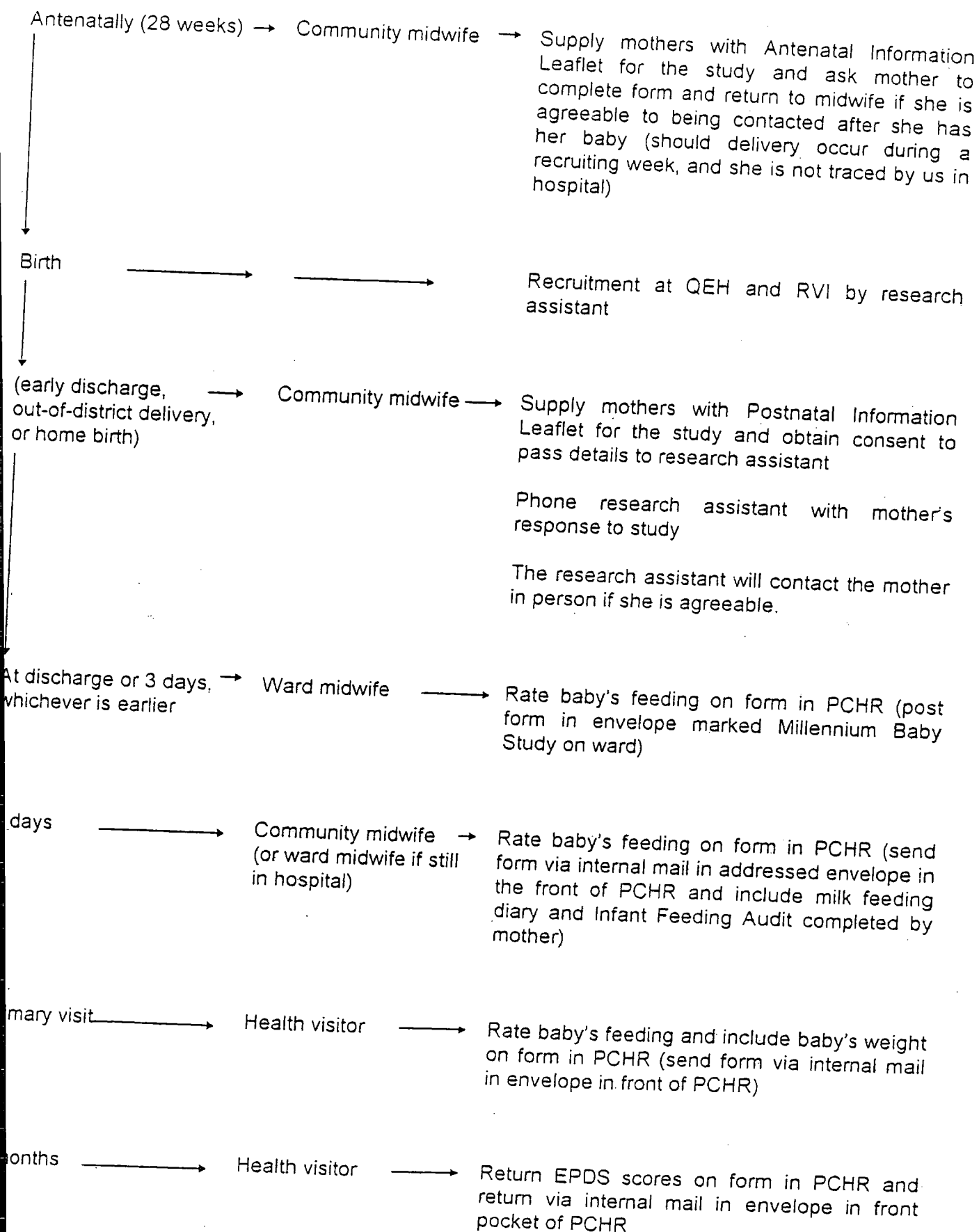
From now on, all health visitors will be completing an Edinburgh Post-Natal Depression Scale (EPDS) by the time the baby is three months old. We would like health visitors to record the score on the carbonated form named Three Month Visit provided in the PCHR and return it to us in the addressed envelope in the front pocket of the PCHR.

This is a large study and we will be getting a great deal of potentially very important information from each family. The information can be used to help families in the future who experience problems with their baby. We hope you will support the study and help to make it a success.

Thank you.

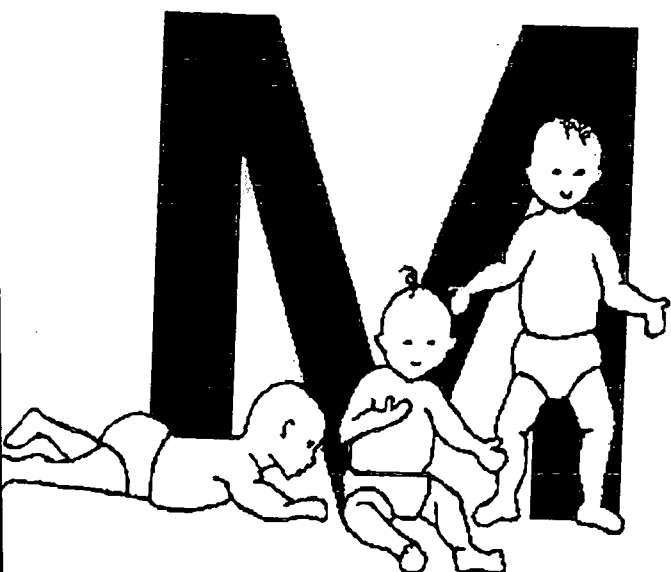
We appreciate your help.

Flowchart of procedures involving NHS staff



Appendix 2

Information sheet for expectant mothers



University of Newcastle
Community Child Health
Donald Court House
13 Walker Terrace
Gateshead
NE8 1EB

Millennium Baby Study: Feeding and Growth Study

New babies are fascinating. How will they turn out? What does the future hold? We want to find out all about the way babies feed, grow and develop, and how this changes as they grow older. We are also interested in how these characteristics vary from baby to baby and in different families.

From June 1999 to June 2000 we will be asking mothers in Gateshead who have a new-born baby to take part in this exciting new study from birth until their baby is one year old. This will involve 1000 Gateshead babies representing all Gateshead residents. We need to study this large number of babies so that we can look at the wide variety which occurs quite naturally in children.

What is the information for?

The information we obtain will be used to improve the care offered to families in future. With your help we should improve the health of babies in the next millennium.

There are more details about the study on the next few pages in the form of questions and answers.

What will I have to do?

Nothing unless you want to and you can decide to do some things but not others. You are free to withdraw from the study at any time without giving a reason. Of course, we hope you will want to be included in all aspects of the study, as the more families who join in the better.

How long will the study go on?

Taking part begins immediately after your baby is born, and information will be collected at intervals until your child's first birthday.

How can I help?

If your baby is born during the recruitment for the study we will contact you to ask whether you are willing to take part. We will be asking half the mothers of new-born babies in Gateshead, depending on which week of the year their baby is born. Those enrolled will receive regular questionnaires (five over the one year period). Some of the questions will be about your baby's feeding, growth, behaviour and development. Others will be about you and your feelings. We would like you to return the questionnaires to us in stamped pre-addressed envelopes.

We will also give you a special Personal Child Health Record in which you will be able to record details of your baby's growth and development. Your midwife and health visitor will also record information about your baby's progress in it when they perform their routine checks. Your Personal Child Health Record will be special because some of the pages of information that you, you midwife and health visitor use will have an extra carbonated copy which we will ask you to provide us with at different times during the study.

We want **everyone**, without exception, who gives birth to a baby during recruiting weeks to be given the chance to take part in the Millennium Baby Study. Mothers sometimes give birth out of the district, or go home very early from hospital afterwards. If you do not mind being contacted when you have had your baby, we would be very grateful if you could fill in the enclosed form and either give it to your midwife or leave it in the posting box in the ante-natal clinic at the Queen Elizabeth Hospital.

Does the study involve anything else?

At around your child's first birthday, we will invite you to bring your child for a special health check. Your child will be seen by the study nurse. She will collect further information from you and your child.

Some of you will be asked if you would like to take part in special studies, with additional measurements made in your home.

This will only be done if you are happy about it.

What if I have difficulty filling in questionnaires?

If for any reason you do not wish to fill in the questionnaires yourself, you might prefer to be visited by the research assistant or answer the questions over the phone. She can then ask you the questions and fill in the form for you.

What about privacy and confidentiality?

This is very important. The questionnaires will only have a number on. Study procedures will ensure that no one outside the study will be able to link the information you give us with your name.

The Millennium Baby Study should be interesting and fun, and your contribution will help many other children in future. We hope you will want to take part.

Further information

If you want to discuss any details please ring the Millennium Baby Study during office hours or write to the address below.

Dr. Kathryn Parkinson, Millennium Baby Study, Community Child Health, University of Newcastle, Donald Court House, 13 Walker Terrace, Gateshead, Tyne & Wear, NE8 1EB.

Telephone: Millennium Baby Study - (Tyneside) 0191 4776000

Do you live within the boundaries of Gateshead Borough?

If so, this study is for you.

If you do not mind being phoned after you have had your baby, we would be very grateful if you could fill in your details below, and either give it to your midwife or post it straight into the posting box in the Antenatal Clinic at the Queen Elizabeth Hospital.

But remember only the babies born to people living in the Gateshead area will be included.

We are only recruiting babies born in certain weeks so please don't be offended if you don't hear from us!

Name

Address
.....
.....

Postcode

Telephone no.

Expected date of delivery

Any other names you might be known under

.....

Please return to:

Dr. Kathryn Parkinson, Millennium Baby Study, Community Child Health,
University of Newcastle, Donald Court House, 13 Walker Terrace, Gateshead,
Tyne & Wear, NE8 1EB.

Telephone: Millennium Baby Study - (Tyneside) 0191 4776000

Appendix 3

Consent form for Millennium baby Study

CONSENT FORM

TITLE OF PROJECT: An investigation of the feeding behaviour in infants who have different patterns of weight gain

The mother should complete the whole of this sheet herself. Signing this form records that consent has been given for the mother and infant to participate in this study.
Please cross out as necessary

Have you read the subject information sheet? YES / NO

Have you had an opportunity to ask questions and discuss the study? YES / NO

Have you received satisfactory answers to all of your questions? YES / NO

Have you received enough information about the study? YES / NO

Who have you spoken to? Dr/Mr/Mrs/Ms/Prof.

Do you understand that all data collected will be kept strictly confidential? YES/NO

Do you understand that you are free to withdraw from the study:

* at any time

* without having to give a reason for withdrawing

YES / NO

Do you understand that as a consequence of withdrawing from the study the video tapes will be wiped clean?

YES/NO

Signed Date

(NAME IN BLOCK LETTERS)

Appendix 4

Recruitment questionnaire



Feeding and Growth Study

ID No.

Recruitment Form

Today's date

day

month

year

1. Mother's name

Personal name Family name

2. Address

.....

.....

Postcode Telephone number

3. Which Council do you pay your Council Tax to?

4. Mother's date of birth

day

month

year

5. No. of previous children

.....

6. Length of gestation

..... weeks

7. Mode of delivery

Normal / Suction / Forceps / Planned Caesarean / Emergency Caesarean

8. Place of birth

.....

9. Number of babies

Single / twins / three or more

10. Baby's name

Personal name Family name

11. Baby's date of birth

day

month

year

12. Sex

Male / female

13. Birth weight

..... g

14. Father's name

Personal name Family name

15. Father's date of birth

day

month

year

16. Would you describe yourself as

Caucasian / Indian Sub-continent / Other Asian / Afro-Caribbean / Other:

17. Would you describe the baby's father as

Caucasian / Indian Sub-continent / Other Asian / Afro-Caribbean / Other:

18. What language do you speak at home?

19. What religion would you describe your family as?

None / Christian / Orthodox Jewish / Non-orthodox Jewish / Muslim / Other:

20. Community midwife

.....

21. Clinic

.....

22. G.P.

.....

23. Would you like help filling in the questionnaires?

ID No. 

Please write the date you complete this: ____/____/____

This questionnaire asks you about you and your new baby.

If, rather than a single baby, you have twins or triplets, please answer the questionnaire in relation to each baby on a different copy of the questionnaire.

If for any reason you do not wish to fill in this questionnaire yourself, you might prefer the research assistant to ask you the questions and fill in the form for you. Please ask and we are happy to help.

How to fill in the questionnaire

1. Some questions on the following pages can be answered simply by putting a tick in the box next to the answer that applies to you.

Example

Yes ☐

No ☐

2. Some questions on the following pages can be answered by circling the response that applies to you.

Example

Not at all — Occasionally — Frequently

If you really feel that you are in-between two of the descriptions, you can indicate this by circling the dotted line.

Section A: Milk feeding

1. How did you feed your baby at birth? (tick one only)
- Breast feeding ☐ Bottle feeding ☐ Both ☐
2. How are you feeding your baby at the moment? (tick one only)
- Breast feeding ☐ Bottle feeding ☐ Both ☐

Section B: General feeding questions

3. So far, how do you rate how well your baby sucks?
Strong---Average---Weak---No opinion
4. So far, how do you rate your baby's appetite?
Very good---Good---All right---Very poor---Poor---No opinion
5. So far, do you think your baby is feeding enough?
Yes---Not always---No
6. Are feeding times for you:
Very relaxed---Relaxed---All right---Stressful---Very stressful
7. Are feeding times for your baby:
Very relaxed---Relaxed---All right---Stressful---Very stressful---Can't tell
8. So far, has your baby been easy to feed?
Very easy---Easy---All right---Difficult---Very difficult
9. So far, has your baby had any trouble with any of the following:
 - (a) Sucking *Not at all---Occasionally---Frequently*
 - (b) Swallowing *Not at all---Occasionally---Frequently*
 - (c) Choking *Not at all---Occasionally---Frequently*
10. Does any of the following describe your baby at present?
 - (a) Has to be woken up for feeds *Not at all---Occasionally---Frequently*
 - (b) Sleeps during feeds *Not at all---Occasionally---Frequently*
 - (c) Cries during feeds *Not at all---Occasionally---Frequently*
 - (d) Slow feeder *Not at all---Occasionally---Frequently*
 - (e) Not satisfied *Not at all---Occasionally---Frequently*
11. Has your baby posseted at all yet (brought up small vomits)?
Rarely---Sometimes---Often
12. Has your baby vomited at all yet (brought up most or all of feed)?
Rarely---Sometimes---Often
13. Do you see your baby as being:
Very thin---Thin---Average---Chubby---Fat

Section C: Looking into the future

These are some questions about how you expect to look after your baby in future.
Please tick the most appropriate response to each question.

14. Some mothers think babies should be fed only when they seem hungry. Other mothers feed their baby whenever they think they need it (for example, if too long a time has passed since the last feeding). Would you

Feed your baby when hungry? ☐ *Feed your baby whenever you think your baby needs it* ☐

Something in between? ☐

15. Many mothers think that a baby's regular feeding should not be delayed and will wake their baby up to feed if it is past the regular time. Would you

Let your baby sleep and ignore the time ☐ *Wake your baby up if it is late for feeding?* ☐

Something in between? ☐

16. What about when your baby cries? If there is no obvious reason for the crying (your baby is not wet, is not hurt), would you

Try to feed your baby? ☐ *Try to calm your baby by other means, without changing the feeding?* ☐

Something in between? ☐

17. Some mothers worry if other people such as friends or relatives think their baby is not gaining enough weight or is too thin. If this happened to you, would you

Encourage your baby to eat? ☐ *Continue with your usual feeding routine?* ☐

Something in between? ☐

18. Suppose your baby has just been fed and about half an hour later becomes fussy and irritable. Would you

Not feed in between regular feedings just because your baby is fussy? ☐ *Try to feed your baby again?* ☐

Something in between? ☐

19. Supposing you were in the middle of watching your favourite TV programme or doing something else you really enjoy, and it was your baby's normal feeding time. If your baby seemed content, would you

Finish what you were doing and then feed your baby? ☐ *Stop what you were doing to feed your baby?* ☐

Something in between? ☐

20. Sometimes when babies get older they seem not to like new foods. Would you

Persist in offering your baby the new food for at least a week before giving up? ☐ *Only try once or twice and then try another food?* ☐

Something in between? ☐

21. When babies are sick with a cold or the flu, they often lose their appetite. If this happened, would you

Try to encourage your baby to eat? ☐

Wait until your baby felt like eating normally again, even if you felt that your baby was not getting enough? ☐

Something in between? ☐

22. Older children often refuse to eat everything they are given at a meal. Would you

Permit your child to refuse? ☐

Encourage your child to eat everything? ☐

Something in between? ☐

Is there anything else you would like to say about feeding your baby?

If so, please give details below:

Section D: General information

23. Please look down the list and state whether you have any of the qualifications listed. Start at the top of the list and tick all the ones that you have passed. (tick all that apply)

(a) Degree (or degree level qualification) ☐

(f) NVQs ☐

(b) Nursing qualifications ☐

(g) No formal qualifications ☐

(c) 'A' levels ☐

(h) Not yet finished education ☐

(d) Scottish highers ☐

(i) Did not go to school ☐

(e) 'O' level passes/GCSE/CSE/GNVQ ☐

(j) Other qualifications ☐

(please state)

24. Does anyone in your household earn a wage at present?

Yes ☐

No ☐

25. Are you (tick one only)

Married, living with husband ☐

Living with partner ☐

Single/separated, living with parents ☐

Single, living alone ☐

Other (please tick and specify) ☐

26. Does your household own or rent your house or flat? (tick one only)

Owens with mortgage/loan/outright ☐

Rents ☐

Rent free ☐

27. (a) Does anyone in your household own a car?

Yes ☐

No ☐

27. (b) If no, do you have the use of a car?

Yes ☐

No ☐

Was there anything you intended to go back to and complete? Please check.

When you have finished please give the questionnaire to the researcher, even if you were not able to answer all of it.

We will be in touch when your baby is six weeks old.

Thank you very much for your help.

Appendix 5

Six week questionnaire

ID No:

This questionnaire asks about you and your baby. If, for any reason, your baby is no longer with you, please tick the box below and return the questionnaire to us so we do not trouble you further.

My baby is no longer with me ☐

The baby's regular carers should fill in this questionnaire. Generally this will be the baby's mother and father, but there may be others who look after the baby such as the baby's grandparents or childminders and it is fine to ask them to help answer the questions.

If you would prefer the research assistant to fill in the form for you, just let us know. We can ask you the questions over the phone, or arrange a home visit.

How to fill in the questionnaire

1. Some questions on the following pages can be answered simply by putting a tick in the box next to the answer that applies to you.

Example

Yes ☒

No ☐

2. Some questions on the following pages can be answered by circling the response that applies to you.

Example

Not at all ~~Occasionally~~ Frequently

If you really feel that you are in-between two of the descriptions, you can indicate this by circling the dotted line.

3. Usually after answering each question you go on to the next one unless a box you have ticked has an arrow next to it with an instruction to go to another question.

Example

Yes ☒ → Go to Question 5

No ☐

WEIGHTS

Please fill in below all your baby's weights written in your Personal Child Health Record since birth. The weight recording page is normally near the end of your record.

You particularly need a weight of when your baby is at least six weeks old. If your baby hasn't been weighed since the age of six weeks, you could either make a special visit to the clinic, or else your baby is due an important doctor's check at eight weeks: the weight from this will be fine. Please write this below before returning the questionnaire.

	Weight (kg)	Weight (lb/oz)

Date	Weight (kg)	Weight (lb/oz)

Section A: Milk feeding

Feeding and growth study: Your baby at six weeks

1. How is your baby being fed at the moment? (tick one only)
Breast feeding ☐ Bottle feeding ☐ Both ☐
2. At the moment, is your baby being fed on demand or generally at set times? (tick one only)
On demand ☐ It depends ☐ Generally set times ☐
3. How often does your baby have milk feeds each day now? times per day
4. (a) Does your baby ever have baby milk in a bottle at present (apart from expressed breast milk)?
Not at all—Occasionally—Frequently
- (b) If so, how many ounces does your baby usually take? (tick one only)
Less than 2oz (60ml) ☐ 2-4oz (60-120ml) ☐ 4-6oz (120-180ml) ☐ More than 6oz (180ml) ☐
- At present, how long does it take to feed your baby?
Less than 5 mins ☐ 5-15 mins ☐ 15-25 mins ☐ 25-35 mins ☐ More than 35 mins ☐

If you have stopped breast feeding since completing the last questionnaire, please answer questions 6 to 8. If not, please go to question 9.

- Never breastfed ☐ → please go to Question 9
Still breastfeeding ☐ → please go to Question 9

Answer the questions in this box if you have stopped breast feeding since filling in the last questionnaire

- How old was your baby when you last breast fed him/her? (tick one only)
Less than one week ☐ 1-2 weeks ☐ 3-4 weeks ☐ 5-6 weeks ☐ 7-8 weeks ☐

Would you have liked to continue breast feeding for longer?
Yes—Possibly—No

Please circle the most appropriate response to each statement about your reasons for stopping breast feeding.

Stopped breast feeding because:

- My baby was not gaining weight
Strongly agree—Agree—Uncertain—Disagree—Strongly disagree
- My baby seemed hungry
Strongly agree—Agree—Uncertain—Disagree—Strongly disagree
- I wasn't producing enough milk
Strongly agree—Agree—Uncertain—Disagree—Strongly disagree
- I had cracked/sore nipples/mastitis etc.
Strongly agree—Agree—Uncertain—Disagree—Strongly disagree
- I thought it was the right time
Strongly agree—Agree—Uncertain—Disagree—Strongly disagree
- My family and friends told me to
Strongly agree—Agree—Uncertain—Disagree—Strongly disagree
- Other (please write the reasons)

Yes, solids given

☐ → please answer questions below

Only answer the questions in this box if your baby has been given solids

Not at all ☐

Occasionally ☐Regularly ☐

..... weeks old

Not at all

Once

More than once

4

☐

□

Too early—At just the right time—Too late

No—By a few days—A week or two—Two to four weeks—Over four weeks

I started solid food because:

Strongly agree—Agree—Uncertain—Disagree—Strongly disagree

Strongly agree—Agree—Uncertain—Disagree—Strongly disagree

Strongly agree—Agree—Uncertain—Disagree—Strongly disagree

Strongly agree—Agree—Uncertain—Disagree—Strongly disagree

Strongly agree—Agree—Uncertain—Disagree—Strongly disagree

Section C: General feeding questions

17. At present, how well does your baby suck?
Strong---Average---Weak
18. At present, how is your baby's appetite?
Very good---Good---All right---Very poor---Poor
19. Overall, is your baby feeding enough?
Yes---Not always---No
20. At present, are feeding times for you usually:
Very relaxed---Relaxed---All right---Stressful---Very stressful
21. At present, are feeding times for your baby usually:
Very relaxed---Relaxed---All right---Stressful---Very stressful---Can't tell
22. At present, is your baby easy to feed?
Very easy---Easy---All right---Difficult---Very difficult
23. At present, does your baby have any trouble with the following:
 - (a) Sucking *Not at all---Occasionally---Frequently*
 - (b) Swallowing *Not at all---Occasionally---Frequently*
 - (c) Choking *Not at all---Occasionally---Frequently*
24. At present, do any of the following describe your baby?
 - (a) Has to be woken up for feeds *Not at all---Occasionally---Frequently*
 - (b) Sleeps during feeds *Not at all---Occasionally---Frequently*
 - (c) Cries during feeds *Not at all---Occasionally---Frequently*
 - (d) Slow feeder *Not at all---Occasionally---Frequently*
 - (e) Not satisfied *Not at all---Occasionally---Frequently*
25. At present, does your baby posset (bring up small amounts of feed)?
Rarely---Sometimes---Often
26. At present, does your baby vomit (bring up most or all of feed)?
Rarely---Sometimes---Often
27. At present, is your baby
Very thin---Thin---Average---Chubby---Fat

Are there anything else you would like to say about feeding your baby?
Please give details below:

Section D: Baby's illnesses

3. Has your baby seen the doctor due to illness, either at home or at the surgery? (tick one only)
No ☐ Once ☐ More than once ☐

4. Since birth has your baby had any of the following? (tick all that apply)

	No did not have	Yes but did not see doctor	Yes and saw/spoke to a doctor
(a) Diarrhoea and vomiting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(b) Cough/cold	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(c) Ear ache/infection/discharge	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(d) Rash	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(e) Chest infection/difficulty breathing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(f) An accident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Has your baby ever been admitted to hospital? (tick one only)
No ☐ Once ☐ More than once ☐

Please describe for each admission

Age of baby (weeks)	Reason for admission	Number of nights in hospital

Section E: Baby's behaviour

Feeding and growth study: Your baby at six weeks

INSTRUCTIONS: Please read carefully before starting:

This section asks lots of questions about how your baby behaves most of the time. Don't think too hard about the answer - tick the response that seems most true for your baby. As you read each description of the baby's behaviour below, please indicate how often your baby did this during the **LAST WEEK** (the past seven days) by circling one of the numbers as illustrated below.

1 = never	2 = very rarely	3 = less than half of the time	4 = about half the time	5 = more than half the time	6 = almost always	7 = always
--------------	--------------------	--------------------------------------	-------------------------------	-----------------------------------	-------------------------	---------------

If you have not seen your baby in the situation described during the last week, move to next section.

If you have seen your baby in this situation during the last week, but your baby never engaged in the behaviour listed, circle 1 = "Never".

Please be sure to circle a number for every item where you saw your baby in the situation.

FEEDING

During feeding, how often did baby:

lie or sit quietly?

squirm or kick?

wave arms?

fuss or cry when s/he had
enough to eat?

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

Did your baby have to wait for food or liquids
during the last week?

No ☐ → go to question 39

Yes ☐

If yes, how often did baby:

seem not bothered?

show mild fussing?

cry loudly?

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

SLEEPING

How often did baby:

seem angry (crying and

fussing) when you left

her/him in the cot?

seem contented when left in

the cot?

cry or fuss before going to

sleep for naps?

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

Before falling asleep at night during the last

week, how often did baby:

show no fussing or crying?

1 2 3 4 5 6 7

During sleep, how often did baby:

43. toss about in the cot?

44. move from the middle to the
end of the cot?

45. sleep in one position only?

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

After sleeping, how often did baby:

46. fuss or cry immediately?

47. play quietly in cot?

48. coo for periods of 5 minutes
or longer?

49. cry if someone doesn't come
within a few minutes?

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

BATHING AND DRESSING

When being dressed or undressed during the
last week, how often did baby:

50. wave his/her arms or kick?

51. squirm and/or try to roll
away?

52. smile or laugh?

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 2 3 4 5 6 7

1 = never	2 = very rarely	3 = less than half of the time	4 = about half the time	5 = more than half the time	6 = almost always	7 = always
--------------	--------------------	--------------------------------------	-------------------------------	-----------------------------------	-------------------------	---------------

Has your baby been put into bath water in the last week? No ☐ → go to question 56

Yes ☐

If yes, how often did baby:
smile?

splash or kick?

turn body and/or squirm?

1	2	3	4	5	6	7
1	2	3	4	5	6	7
1	2	3	4	5	6	7

When face was washed, how often did baby:
smile or laugh?

cuss or cry?

1	2	3	4	5	6	7
1	2	3	4	5	6	7

Has your baby's hair been washed in the last week? No ☐ → go to question 60

Yes ☐

If yes, how often did baby:

smile or laugh?

cuss or cry?

1	2	3	4	5	6	7
1	2	3	4	5	6	7

DAILY ACTIVITIES

How often during the last week did baby:

or show distress at a loud

sound (blender, vacuum
cleaner, etc)?

or show distress at a

change in parents'

appearance (glasses off,

lower cap on, etc.)?

after startling?

1	2	3	4	5	6	7
Not seen						
1	2	3	4	5	6	7
Not seen						
1	2	3	4	5	6	7
Not seen						

When being held, how often did baby:

arm, pull away or kick?

1	2	3	4	5	6	7
---	---	---	---	---	---	---

When placed on his/her back, how often did

or protest?

or laugh?

quietly?

arms or kick?

turn and/or turn body?

1	2	3	4	5	6	7
1	2	3	4	5	6	7
1	2	3	4	5	6	7
1	2	3	4	5	6	7
1	2	3	4	5	6	7

Has baby been placed in an infant seat or car seat? No ☐ → go to question 73

Yes ☐

If yes, how often did baby:

69. wave arms or kick?

70. squirm and turn body?

71. lie or sit quietly?

72. show distress at first, then
quiet down?

1	2	3	4	5	6	7
1	2	3	4	5	6	7
1	2	3	4	5	6	7
1	2	3	4	5	6	7

73. Have you returned from being away and baby was awake? No ☐ → go to question 74

Yes ☐

If yes, how often did baby:
smile or laugh?

1	2	3	4	5	6	7
---	---	---	---	---	---	---

Have any of the following soothing techniques been tried on baby in the last 2 weeks? If so, how often did the method succeed in soothing baby?

74. rocking

75. holding

76. singing or talking

77. walking with baby

78. giving baby a toy

79. showing baby something to
look at

80. patting or gently rubbing
some part of baby's body

81. offering a feed

82. changing baby's position

83. other (please specify)

1	2	3	4	5	6	7
Did not try						
1	2	3	4	5	6	7
Did not try						
1	2	3	4	5	6	7
Did not try						
1	2	3	4	5	6	7
Did not try						
1	2	3	4	5	6	7
Did not try						
1	2	3	4	5	6	7
Did not try						
1	2	3	4	5	6	7
Did not try						
1	2	3	4	5	6	7
Did not try						
1	2	3	4	5	6	7
Did not try						

Was there anything you intended to go back to and complete? Please check.

Please make sure you have filled in the weights on the first page.

Who completed this questionnaire? (tick all that apply)

Baby's mother ☐

Baby's father ☐

Baby's grandparent ☐

Nanny ☐

Childminder ☐

Nursery ☐

Other (please tick and specify) ☐ :

How old is your baby now? weeks and days

Please write the date you complete this ____ / ____ / ____

It would help us in our record keeping if you write your name here

If the name or address on the envelope was not correct or incomplete, or if you expect to move house in the near future and know your new address, it would help us if you could write it below:

.....
.....
.....
.....

When you have finished please return the questionnaire in the enclosed envelope even if you were not able to answer all of it.

Thank you very much for your help.

We will be back in touch with you when your baby is three months old.

Dr. Kathryn Parkinson
Community Child Health
University of Newcastle
3 Walker Terrace
Gateshead
Tyne & Wear
NE8 1EB

el: Tyneside (0191) 4776000

Appendix 6

Additional information sent to health professionals

Information for health visitors.

An investigation of feeding behaviour in infants with different patterns of weight gain.

The Department of Child Health at Newcastle University is currently conducting a study of sucking patterns in infancy, using a sub-sample of infants recruited into the Millennium Baby Study. Fiona Colquhoun, a colleague from Durham University will be conducting the study.

We would like you to be aware that the study is taking place, but **it does not require any action from you.**

The purpose of this research is to study the feeding behaviour of infants who have different patterns of weight gain over the first eight weeks after birth. The subjects will be approximately 200 infants recruited from the Millennium Baby Study.

Procedure

Pre-Study Visit

Fiona Colquhoun will initially contact each mother by phone to discuss the research and arrange to visit the mother 3 days prior to the expected day of study if agreeable. During this visit, Fiona will explain the procedure to the mothers and answer any questions. The mother will be given a milk feeding diary to be completed 24 hours before the next agreed visit. This diary will be the same as that in the PCHR the mothers fill in after birth.

Day of Study

On the following day, Fiona will visit the mother and infant and will observe the mother and infant for two consecutive feeds. Each of these feeds will be video recorded. These data are analysed afterwards using a computer program that requires the researcher to manually input each observed suck. If the baby is breast fed, the infant will be weighed before and after feeding. If the infant is bottle fed, the weight of the bottle will be measured, and a sample of the formula taken.

If you have any queries about the study or would like any further information please contact Fiona Colquhoun.

Fiona Colquhoun
Science Laboratories
South Road
Durham DH1 3LE
Tel: Main Office (0191) 374 2600
Tel: Direct (0191) 374 4606
Email: F.S.Colquhoun@durham.ac.uk

Appendix 7

Letter to mothers about the observational
feeding study



UNIVERSITY OF
NEWCASTLE



Date

Name

Address

Department of Child Health

Community Child Health
Donald Court House
13 Walker Terrace
Gateshead NE8 1EB

Dear

Millennium Baby Study: Feeding and Growth Study

Thank you for completing and returning the questionnaire we sent about your baby at six weeks. We are now asking some of the families in the study if they would be willing to help with a more detailed investigation of early sucking behaviour. Would you be interested in taking part?

Fiona Colquhoun from Durham University is carrying out this research in close collaboration with us. The aim is to study sucking patterns in young babies during milk feeds in different babies. The study is purely observational involving two short visits on the same day.

Fiona will not be asking you to change your baby's feeds in any way. She will phone you shortly to arrange a time to come and discuss the study with you and ask whether you are interested in taking part.

If you would like any further information about Fiona's study, please feel free to contact either myself at the above address or Fiona on (0191) 374 2600

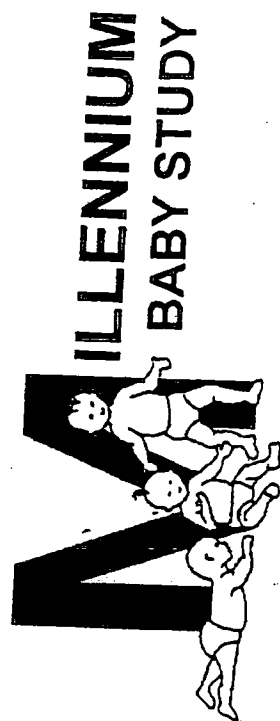
Best wishes

Kathryn Parkinson

Kathryn Parkinson
Study Co-ordinator

Appendix 8

Information sheet for mothers



EARLY INFANT FEEDING AND GROWTH STUDY

**Information for
participants**

What is the early infant feeding and growth study ?

We are very pleased that you and your baby are taking part in the Millennium Baby Study, in which detailed records are being kept of the growth and development of a thousand babies in Gateshead. We are now asking some of the families in this study if they would agree to our making more detailed observations on the feeding of their babies.

Why have you chosen my baby ?

We have chosen babies with a variety of growth patterns so that we can find out more about the feeding behaviour and milk intake of babies with different growth patterns.

What will we have to do ?

You will not be asked to change your baby's feeds in any way. I would like to visit you and your baby in your home just once more after today's visit. Today we will discuss the details of the study and I will give you a milk diary, to record your baby's feeds for two consecutive days before my next visit. On my next visit I will observe your baby for two consecutive milk feeds and make a video recording of each feed.

What will happen on the second visit ?

I will make a video of your baby's first feed, and then come back later and videotape the second feed. I will also measure your baby's current weight and length.

If your baby is breast fed, he/she will be weighed before and after each feed to find out how much milk has been taken.

If your infant is bottle fed, I will take details of the type of formula used as well as a small sample of the formula before the feed.

What about confidentiality ?

I will keep all the information we collect in a secure place and it will not be seen by anyone outside the research team. You will not be identifiable on the video tape and it will be destroyed at the end of the study.

What do I have to do now ?

Nothing if you don't want to. We will be very pleased if you would agree to these more detailed observations and if you are happy to proceed I will ask you to sign a consent form and we will arrange a convenient time for me to make my second visit.

What if I change my mind ?

Of course you are perfectly free to choose not to participate in this part of the study if you wish and to drop out of the study if you change your mind later. It will have no effect on your part in the main study.

Please ask if you have any questions or would like any additional information.

Ms Fiona Colquhoun

Postgraduate Student

Telephone 374 4606

Department of Psychology
Durham University

Study Supervisors

Dr. Charlotte Wright

Consultant Paediatrician /

Senior Lecturer

Dr Robert Drewett

Reader in Health Psychology

Durham University

Telephone 477 6000 University of
Newcastle-upon-Tyne

Appendix 9

Consent form for mothers

CONSENT FORM

TITLE OF PROJECT: An investigation of the feeding behaviour in infants who have different patterns of weight gain

The mother should complete the whole of this sheet herself. Signing this form records that consent has been given for the mother and infant to participate in this study.
Please cross out as necessary

Have you read the subject information sheet? YES / NO

Have you had an opportunity to ask questions and discuss the study? YES / NO

Have you received satisfactory answers to all of your questions? YES / NO

Have you received enough information about the study? YES / NO

Who have you spoken to? Dr/Mr/Mrs/Ms/Prof.

Do you understand that all data collected will be kept strictly confidential? YES/NO

Do you understand that you are free to withdraw from the study:

* at any time

* without having to give a reason for withdrawing YES / NO

Do you understand that as a consequence of withdrawing from the study the video tapes will be wiped clean?

YES/NO

Signed Date

(NAME IN BLOCK LETTERS)

Appendix 10

Milk diary

FEEDING DIARY Please record your baby's feeds (milk & solids) for two consecutive days

I.D. no

Baby's Name _____ Date of birth ____ / ____ / ____

[illegible]

Appendix 11

Data sheet for breast fed infants

Millennium Baby Study
Subject Details

ID Number /

Mother's First Name

Mother's Surname

Baby's Name:

Date of Birth:
Day Month Year

Address:

Post Code

Telephone No.

Notes:

Millennium Baby Study

Breast Fed Babies

ID Number /

Date
Day Month Year

Date of Birth
Day Month Year

Gender: Male / Female

Length of baby . cm

Weight of undressed infant . kg

Meal 1

1. Time of feed .

Weight of baby after feed . kg

Weight of baby before feed . kg

Volume taken g

Meal 2

2. Time of feed .

Weight of baby after feed . kg

Weight of baby before feed . kg

Volume taken g

Note! All feed weights are for a dressed infant.

Appendix 12

Data sheet for bottle fed infants

Millennium Baby Study Subject Details

ID Number /

Mother's First Name

Mother's Surname

Baby's Name:

Date of Birth:
Day Month Year

Address:

Post Code

Telephone No.

Notes:

Millennium Baby Study

Bottle Fed Babies

ID Number /

Date
Day Month Year

Date of Birth
Day Month Year

Gender: Male / Female

Weight of baby undressed . kg

Weight of baby dressed . kg

Length of baby . cm

Meal 1

1. Time of feed .

Weight of bottle before feed . g

Weight of bottle after feed . g

Volume taken . g

Teat Type:

Manufacturer

Brand name

Teat size

Rubber/silicone

Type of milk:

Manufacturer

Brand name

Derived from

Sodium content

Sample taken & coded ? First feed ☐

Millennium Baby Study

Bottle fed babies

Meal 2

2. Time of feed .

Weight of bottle before feed . g

Weight of bottle after feed . g

Volume taken . g

Teat Type:

Manufacturer

Brand name

Teat size

Rubber/silicone

Type of milk:

Manufacturer

Brand name

Derived from

Sodium content

Sample taken & coded ? Second feed ☐

Appendix 13

Teat information

Manufacturer	Teat Type	Details	Teat Range	No. of holes	Recommended for
AVENT Cannon Rubber Ltd Lower Road Glensford Suffolk England CO10 7QS Tel: 01787 267000 Fax: 01787 267001	Silicone	Shaped to mimic breast In form and function	Newborn Teat	1	NewBorn Promoting vigorous sucking
			Slow Flow	2	small feeds - juice or water
			Medium Flow	3	
			Fast Flow	4	
			Variable Flow teat	Single Slot	3 Months + By turning the bottle, flow can be manipulated throughout the feed. Faster at the beginning, slower at the end.
NUK MM Distributors Ltd 6 Senate Place Whitworth Road Stevenage Herts SG1 4QS	Latex/ Silicone	Teat designed by an Orthodontist to simulate breast feeding. Also, vented to reduce colic	Size 1:		0-6 Months
			Small	1	To be used for water
			Medium	1	To be used for milk
			Large	1	For hungry babies who need a fast flow to satisfy their appetite

Manufacturer	Teat Type	Details	Teat Range	No. of holes	Recommended for
NUK cont... MM Distributors Ltd 6 Senate Place Whitworth Roa Stevenage Herts SG1 4QS Tel: 01438 351341			Size 2: Small Medium Large	 1 1 1	6-18 Months
MAWS	VARIFLO	Cross cut teat	One size		Cross cut at the end which opens when the baby sucks. The harder the baby sucks, the more the cross opens and milk comes out. The teats are Variflotm because the flow rate adjusts automatically and so one teat suits all babies.
Jackel International Ltd FREEPOST Dudley Lane Cramlington Northumberland NE23 7RH Tel: 0500 97 98 99					

Manufacturer**TOMMEE TIPPEE**

Jackel International Ltd
FREEPOST
Dudley Lane
Cramlington
Northumberland

NE23 7RH

Tel: 0191 250 1864
Fax 0191 250 1727

BOOTS

Tel: 0845 840 2000

Teat Type	Details	Teat Range	No. of holes	Recommended for
Latex/ Silicone	soft & natural, though not hard wearing	Medium	1	3-6 Months
		Fast Flow	1	6 Months +
		Orthodontic	1	Hole is positioned on the flat side as opposed to the tip of the teat. Hole is positioned facing upwards, towards the roof of the baby's mouth during feeding.
Silicone	Man made. Tasteless	Medium	1	3-6 Months
		Fast Flow	1	6 Months +
Latex	Soft rubber, deteriorates quickly.	Medium	1	
		Orthodontic	1	Assist dental development.
Silicone	Clear hard wearing material, easier to clean.	Standard	1	For use on standard size bottles.
		Wide	1	For use on wide necked bottles.

Appendix 14

Brand information

Summary of different brands of formula milk used in this study and their corresponding sodium contents

Brand of formula milk	Sodium per 100ml of re-constituted formula
Cow & Gate Plus	24 mg
Cow & Gate Premium	19 mg
Farley's Second	19 mg
Farley's White	21 mg
Milupa Aptimil Extra	20 mg
Milupa Milumil	25 mg
SMA Gold	16 mg
SMA White	22 mg

